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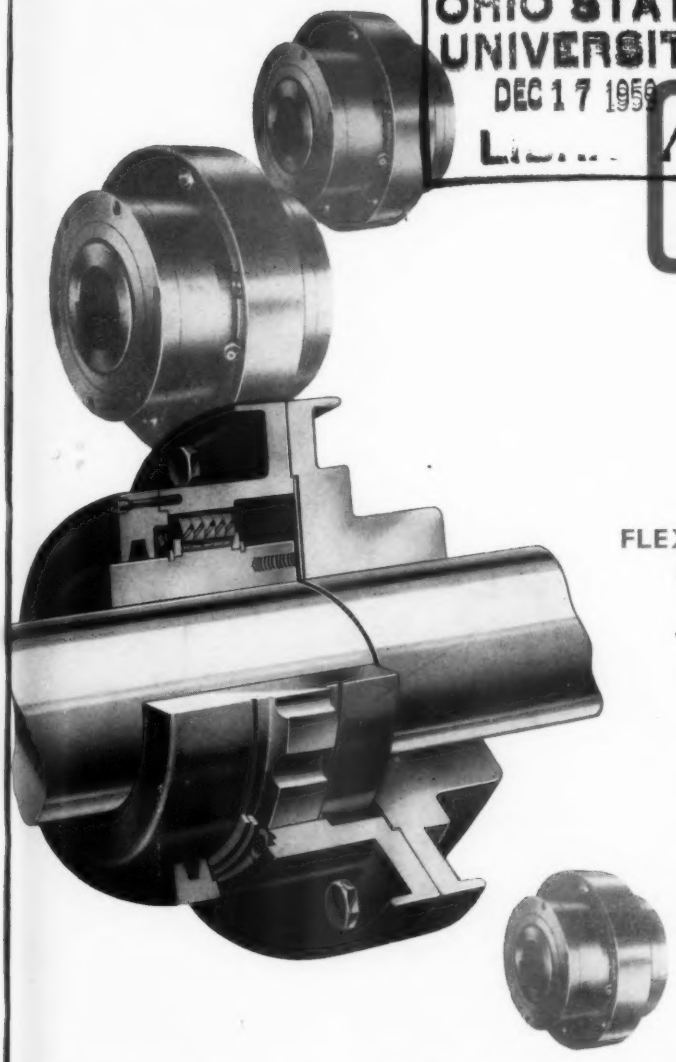

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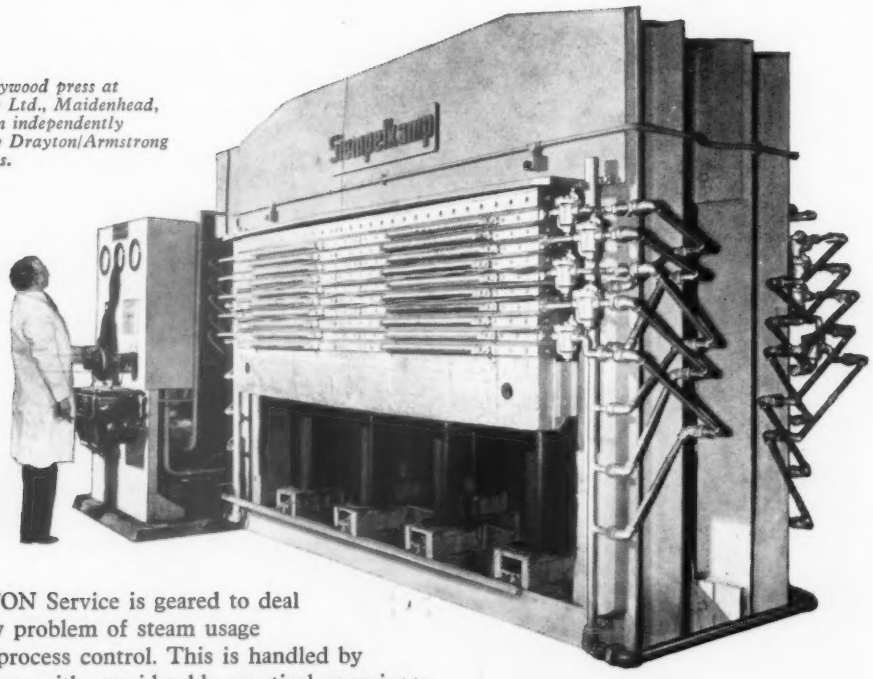

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Mechanical World —— November 1959

Precision Metallurgy

MANY engineering materials are known in more than one form, and additional to the traditional wrought and cast forms there are variations like rolled, drawn and diecast which belong to modern history, and more recent times still have seen introduction of the electrolytic and the powder metallurgical forms.

The change from the hand wrought and the hand moulded forms to rolling, drop forging, machine moulding and diecasting, naturally had intrinsic metallurgical significance and consequences, but from the engineering viewpoint one of the important results was the access of a higher degree of dimensional accuracy "in the black". With certain knowledge of the dimensional tolerances of the "black" parts, it became possible to reduce the extent of machining and, furthermore, to realize the benefit of the homogeneous component.

What is possibly the highest attainable accuracy in casting was, of course, all the time in existence as an established technique of the jeweller. This was the lost wax process which was pressed into service when it was desired to make blades for gas turbines from materials which, at the time, were practically unmachinable. The balance has since been largely restored, but precision, where it is required, in the casting process has acquired increasing refinement by the use of this and by the introduction of other new processes.

The metallurgical background to these various developments has been very largely the control of the macroscopic form, though with the coming of the electron microscope and thus a near visualization of the ultimate particles, the sphere of control will certainly move more towards the microscopic. Almost in anticipation of this has been the mechanically imitative process of powder metallurgy. Out of a need to control composition uniformly throughout the part recourse has been had to reducing the components to the finest possible powders, mixing them uniformly and then raising their status from the discrete to the compact. Powders which are sufficiently fine for molecular forces to be uncovered adhere simply upon being compressed, as happens in pressure welding. With them secured in this way a sintering process brings the whole to whatever degree of solidity may be required for a particular application.

The above discussion shows at least two trends: one is towards accuracy of form in the final process in the metallurgical sequence, as opposed to gross manufacture with subsequent reduction to size accompanied by waste; and the other is the tendency to seek control by moving away from the composite structure and towards the component particle. Logically this is the ideal if it can be taken far enough, but "far enough" means into the realms of the elementary atoms. That, of course, is where the energy producing industry is already successfully entrenched. Will it be long before metallurgy is similarly in sight of its ultimate possibilities?

LOG SHEET

A.E.I Computer Under Test

The first production model of the Central Computing Unit of the A.E.I. 1010 Data Processing System manufactured by the A.E.I. Electronic Apparatus Division at Trafford Park, Manchester, was completed on schedule and is now undergoing tests. Various items of peripheral equipment are being added and tested with the computer, which will be installed in a Computer Centre in the Manchester area by the end of this year.

A realistic policy of testing and proving the computer installation is being pursued by the division, which is not accepting orders for delivery before early 1961, by which time the first installation will have been running for a year.

An introductory course on the 1010 Data Processing System was held recently in the Trafford Park Works, and was attended by representatives from a number of firms and organizations who are prospective customers for the 1010. These courses are to be repeated at regular intervals.

Programming courses will be started early next year at the Computer Centre where the 1010 Data Processing System will be available for customers and prospective customers, to run and prove programmes written for their own applications.

The A.E.I. 1010 Data Processing System (previously announced as the Metrovick 1010) is more than four times as fast and twice as powerful as any other system available in the same price range. It has been specially designed so that a medium sized installation costing about £150,000 can be expanded at will as data processing requirements grow. This is done by the addition of new ancillary equipment without any change to the Central Computing Unit being necessary.

A very powerful and flexible system can be built up which is capable of controlling up to 32 peripheral units, such as magnetic tape decks, paper tape and card readers, line printers, enquiry typewriters and paper tape and card punches. Facilities are available for parallel programming, interruption to execute priority work and multiple input and output. The computer is completely transistorized and can execute some 70,000 data processing instructions every second.

Electronic Parts Control

The first electronic control system to be used in the fork truck industry has been installed at The Yale & Towne Manufacturing Company's Materials Handling Division at Philadelphia, U.S.A., to speed deliveries of spare parts and ensure adequate stocks at each of the 15 Yale depots and branches in the United States.

The control, known as the IBM Memory Marvel, RAMAC 305, can store up to 5,000,000 characters of inventory and accounting data on Yale materials handling equipment spare parts. It computes the demand for spare parts in each section of the country, and shows the minimum stock requirements at each depot.

To ensure good parts service, IBM RAMAC reduces to an absolute minimum the repetitive clerical functions of order editing, pricing, manual calculations, order typing and other manual functions in connexion with parts transactions.

All these functions are processed electronically by the use of pre-punched, pre-verified card data at speeds seven times faster than manual typing, resulting in greatly reduced order processing time with exceptional accuracy.

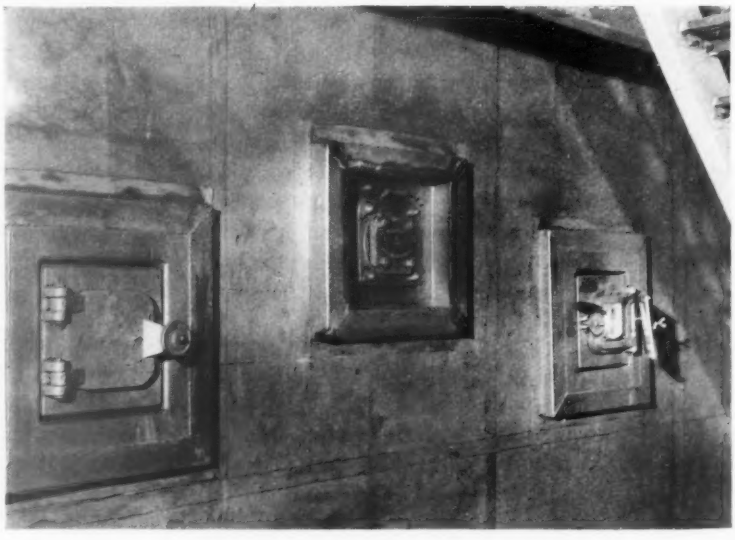
Through stored programmes, RAMAC daily computes usage and inventory status in all locations to determine if re-order points for any parts have been reached. When these points are reached, the machine calculates from usage data the quantity that should be ordered to maintain the particular location's stock at a full operating inventory level.

The in-line procedures accomplished by RAMAC produce output punch cards containing order data for parts procurement. This integrates the parts control programme electronically with existing Yale IBM production control procedures in manufacturing plants and automatic purchase order writing for supplier-manufactured items.

Within seconds of an enquiry, RAMAC reveals the national inventory status in all branches and depots of the Yale parts required. Minutes later teletype messages are sent to the nearest depot or branch and shipment is made immediately to get the user's Yale trucks back into operation.

Hindley Green

In 1871 three brothers, John, Samuel and Robert Turner, bought some second-hand machinery, and taking over part of their father's mill



EPOXY RESINS FOR BOILER WALL LAGGING.—The insulation on this Clark-Chapman boiler at the Stella North Power Station, near Newcastle upon Tyne, has the insulation finished with asbestos cement to which P.V.C. fabric has been bonded with 'Araldite' epoxy resin. This method of lagging, by The Darlington Insulation Company Limited, has proved most satisfactory and is about one-third the cost of the normal method of metal cladding. The 'Araldite' and P.V.C. combination was found to be suitable for withstanding the outside temperature of the boiler walls and at the same time flexible enough to cope with boiler expansion

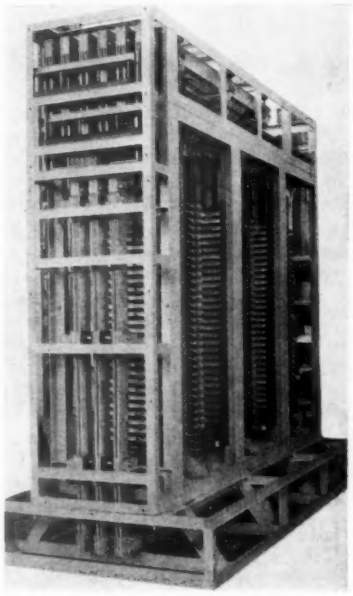
in Rochdale began to manufacture cotton-based products for industry. Success was not immediate, but opportunity came in 1878 when a forest fire in Quebec laid bare a deposit of asbestos. The brothers immediately realized the potential of the material and, succeeding in spinning it by machinery, laid the foundation of Turner Brothers Asbestos Company Limited whose Rochdale factory has become the largest of its kind in the world, and who have earned a reputation which extends into every country where industry exists.

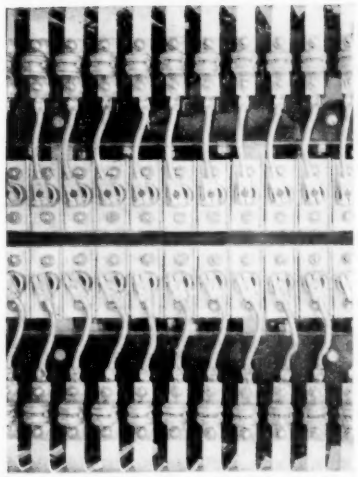
Recently, the opening of the South Block at the company's new premises at Hindley Green, near Wigan, marks the completion of one of the most important industrial developments in Lancashire since the war. To commemorate the inauguration of the new factory the company has published a brochure which details briefly the growth of the company and shows some of the progressive spirit and enterprise which energizes the organization. (Any reader can have a copy by writing to the Company).

The Hindley Green factory as a whole—North and South Blocks—covers an area of 1,000,000 sq ft. The North block is given over to the manufacture of power transmission and conveyor belting, and the South Block to various asbestos textiles, mainly brake lining materials, a large proportion of which are supplied to Ferodo Limited, an associated company. Glass textiles and resinated asbestos moulding materials are also produced.

3300 KW Silicon Rectifier

What is believed to be the largest silicon rectifier equipment made in Britain has been completed by Westinghouse Brake and Signal Company Limited and is being shipped to India to provide current for electrolytic cells producing chlorine and caustic. The rectifier plant, which uses silicon diodes made in the Chippenham Works of Westinghouse, is rated at 27,500 amp at 60–120 volts d.c., and comprises a regulator and transformer connected to the 22 kV system, a water-cooled silicon rectifier, and a control cubicle with automatic adjustment of the d.c. current so that the rate of production of chlorine is maintained constant.





The compact design of the Westinghouse silicon rectifier is illustrated by this 14,000 amp 120 V cubicle which occupies a floor space of 4 ft 6 in. by 12 ft 8 in. Current is evenly shared among the paralleled silicon diodes by means of equalizing reactors, thereby avoiding any necessity to select diodes of matched characteristics

The rectifier is compact, a floor space of 57 sq ft being required for each of the two cubicles—which could be uprated to double the operating voltage by selecting silicon diodes withstanding 1000–1200 V peak which Westinghouse are now producing in good quantities—each diode delivering up to 10 kW.

Silicon rectifiers have been chosen on account of the high temperature: germanium offers a slightly superior efficiency below 100 volts d.c. or so where the climatic conditions allow of its use. Westinghouse are building several large germanium rectifiers such as 18,000 amp at 95 V for Tasmania and 14,000 amp at 70 V for Holland where cool conditions prevail, while for hotter climates Westinghouse choose silicon for such contracts as 12,000 amp at 110 V for Israel, 9000 amp at 80 V for Turkey, and for other plants in Pakistan employed for hydrogen production.

Control Centre Tests

Tests under fault conditions of the new multi-motor control centre (Type MMC series 1000) developed by Associated Electrical Industries Motor & Control Gear Division have been satisfactorily completed at an ASTA Testing Station. The equipment is designed to provide outstanding flexibility. It can accommodate starters up to 250 hp, switch fuses up to 400 amp, and air circuit breakers up to 1600 amp.

At the testing station the control centre was subjected to through fault tests on the different bus-bar arrangements available at various fault levels with a maximum of 49·7 kA symmetrical R.M.S. for 3 sec. This enables the board to be offered with a tested through fault rating of up to 55 MVA at 660 volts for 3 sec.

Further tests with 440 A.C.5 fuse cartridges in the drawout equipment trays and with a fault simulated at the outgoing terminals were made when connected to a 440 volt system having a prospective fault current of 46 kA.

Hydrogen Cooling at Willington-A

The new Willington-A power station of the Central Electricity Generating Board is distinguished in being the first station to use English Electric's fully direct hydrogen cooled alternator. The station is also the first to be equipped with English Electric 100,000 kW generating units.

The hydrogen cooled alternator is of the same physical size as the other three units and has been installed to provide early operating experience of the cooling technique now being adopted for machines of much larger rating.

Circulating hydrogen under pressure directly through the stator and rotor conductors makes it possible greatly to increase the output of a machine without increasing the overall size and weight. With this technique, machines with one piece stators much larger than that of the 200,000 kW High Marnham unit can

now be built and moved within the existing transport limitations.

The change to generating units of larger rating than those employed in earlier stations follows the Board's progressive policy to reduce generation costs. The 100,000 kW rating is considered to be the optimum size for non-reheat type machines in this country and so represents a transitional stage between the established 60,000 kW rating and the reheat machines which are currently being supplied as standard units up to 275,000 kW with even larger machines in prospect.

Tonnage Oxygen Plant

Appleby-Frodingham Steel Company, a branch of The United Steel Companies Limited, are installing a tonnage oxygen plant at their Scunthorpe works at an estimated cost of £750,000. Site work has already begun and the plant is expected to be in commission by the late summer of 1960.

Intended for the continuous production of gaseous oxygen for metallurgical and combustion purposes, the new plant is being designed to produce 100 tons of gaseous oxygen per day of 99·5% purity at 600 psi gauge, and ambient temperature. Alternatively, 90 tons of gaseous oxygen and 10 tons of liquid oxygen per day can be produced so that the latter can be stored and evaporated to cover planned stoppages of the main plant.

Principal contractors for the tonnage oxygen plant are Air Products (Great Britain) Limited, the British subsidiary of Air Products Incorporated, of Allentown, Pennsylvania, U.S.A. All the structural steelwork is being fabricated by United Steel Structural Company Limited, a United Steel subsidiary, and the complete installation will be carried out by Woodall-Duckham, Limited.

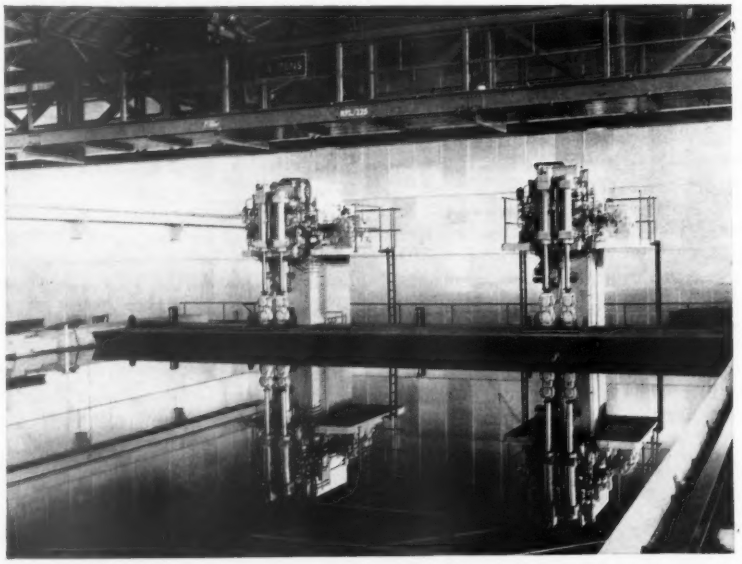
Universal Beams

Universal beams, I-sections with parallel edges and column sections are becoming increasingly popular with structural engineers, principally because they offer appreciable savings in the weight of structural steel compared with conventional British Standard rolled steel beams. Appleby - Frodingham Steel Company, a branch of The United Steel Companies, Limited, are to extend their Frodingham section mills by the addition of equipment to produce universal beams, I-sections with parallel edges, and column sections.

A contract has been placed with Schloemann A.G., of Dusseldorf, but the equipment will be manufactured in Britain. Schloemann have placed an order with Distington Engineering Company Limited, a United Steel subsidiary, for the supply of the mechanical equipment. Work on the project has already begun at Distington, and the new extensions are expected to be in operation by the autumn of 1961. No increase in the overall capacity of the Frodingham section mills is envisaged, nor will there be any substantial increase in manpower.

Ship Hydrodynamics Laboratory

A towing tank at Feltham is the major part of the new Ship Hydrodynamics Laboratory opened by HRH the Duke of Edinburgh on October 19. Built for the Ship Division of the National Physical Laboratory, the purpose of the tank is to test large ship models under simulated sea conditions. Models up to 40 ft long, weighing 5 tons, can be used. The tank is 1,300 ft long, 48 ft wide and holds 10 million gallons of water.

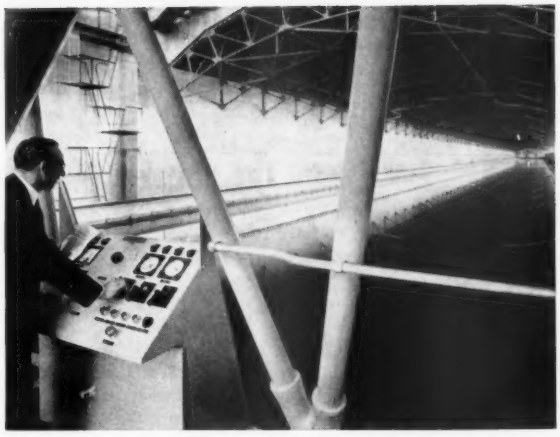


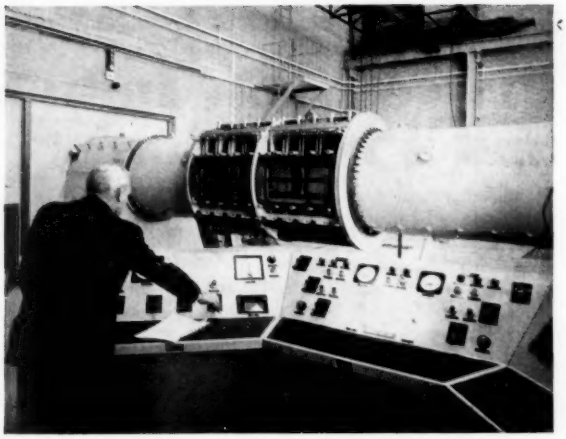
West end of the 1300-ft long towing tank at the Ship Hydrodynamics Laboratory Feltham, showing the electro-hydraulic wave-making equipment

To test the model ships it is necessary to make accurate scale model waves. This is done by oscillating a large wedge-shaped plunger, weighing 20 tons. Great accuracy of movement has to be maintained, with no greater error than $\frac{11}{16}$ in. at any time. To achieve this formidable task Keelavite Hydraulics Limited of Allesley, Coventry, were asked to design an hydraulic power system, which could be controlled by electronics. The resulting electro-hydraulic servo system pioneers the precisely controlled movement of large masses. The wave conditions required are pre-set on a small control panel, the system then takes charge, making its own corrections for errors which arise during operation. The key to the problem of accurate control is the use of the newly developed Keelavite electro-hydraulic servo valve.

The laboratory also includes a water tunnel with a measuring section 44 in. dia: a sea-keeping and manoeuvring basin 100 ft square, together with the necessary workshops for making model hulls and propellers, a vibration laboratory, and instrument laboratories for testing and calibration.

These new and up-to-date facilities for hydrodynamic research and development, designed to reproduce in the laboratory more nearly realistic sea conditions than has been possible in the past, will now be at the service of British shipbuilding. The main aim of the research will be to make it possible to design ships that can maintain high speeds in rough seas





On the 1300 ft ship testing tank, entire control of the 40 ton carriage which tows ship models of up to 5 tons in weight and 40 ft in length is carried out from the compact English Electric control desk, seen on the left. Electronic speed-holding control maintains any set test speed between 1 and 50 ft per second within 0·1%. On the water tunnel at the laboratory, entire control of the water speed (up to 50 ft per sec), pressure and dynamo meter speed is carried out from the three-section control desk shown in the other picture. The desk also accommodates all the instruments for indicating the effects of tests on propellers in the tunnel. English Electric are the main electrical contractors for the whole project

without danger and with a minimum of discomfort.

The Superintendent of the Ship Division, NPL, is Dr. F. H. Todd, who returned to Teddington in 1957 after nine years in the United States as Technical Director at the David Taylor Model Basin, Washington, D.C.

The Acru Electric Tool Manufacturing Company Limited, Cheadle, formerly of Manchester, supplied surface tables to the laboratory including one measuring 70 ft in length. This table is the largest ever made in this country, and possibly one of the largest in the world, with an accuracy of only ± 0·002 in. over the whole length. There are obviously tables longer than this, but not with such a close accuracy.

A further point of interest is that when assembling the table the curvature of the earth had to be taken into consideration when measuring with spirit levels, as over 70 ft the earth's curvature is approximately 0·0005 in.

The surface tables are made of close-grained cast iron and were first rough machined before putting in the open for one year to age. The final machining then took place. The largest table is made in seven sections each of 10 ft length, and bolted together in such a way that the joints are level. The castings are absolutely free from blow holes and porous patches, which is an achievement in itself, since over such a large area it is very difficult to obtain perfect surfaces.

Mechanical Camel

The world's largest truck, 16 ft in width and travelling on tyres that would dwarf the tallest men, was driven from New Orleans, Louisiana, to Tulsa, Oklahoma, U.S.A., with a police escort nearly all the way. The powerful vehicle, built by Automobiles M. Berliet of Lyons, France, for use in soft, sandy terrain, considered impassable for ordinary vehicles, arrived in the U.S. for display at the International Petroleum Exposition.

The truck can carry payloads of 100 tons over all types of terrain, using tyres that could be compared to a camel's feet. The eight-foot tyres, manufactured by the Goodyear Tire & Rubber Company in the U.S.A., were designed so that the ground pressure simulates that of the animal's feet on desert sand.

The gigantic Berliet T-100, designed for use in the exploitation of natural resources in inaccessible areas, is 16 ft wide, 13 ft high and 41 ft long. It arrived in New Orleans from France aboard the freighter *Dagrun* and was placed on display for two days.

The bearing area of all six tyres comes to a total of 100 sq ft which, for a 100-ton truck, results in a pressure of 14 psi the same as a camel's feet. Because of the relatively low pressure of the tyres, the Berliet T-100 can travel easily over long distances and virtually all surfaces, and despite its size it is driven with relative ease because of numerous "power assists" incorporated in its design. These include power steering, power brakes and a power-assisted gear shift, which has eight forward speeds and eight reverse. It is equipped with a 600 hp turbo-diesel engine.

The cab, called "Cabine Relaxe", includes a filtered air conditioner to keep the compartment at the proper temperatures, comfortable five-abreast seats and two sleeping berths, a fully-equipped instrument panel, a cooking range and drinking water tanks. A two-way radio is provided to keep the operator in constant touch with his base, even as far as 200 miles away.

Silicone Rubbers

Midland Silicones Limited have promoted their cold curing silicone rubbers from an experimental to a bulk production basis, resulting in the products now being manufactured to specifications ensuring greater consistency, and assuring continuity of supply.

The great advantage of these simple-to-use products is that they need no heat cure: the addition of a small quantity of catalyst converts them at room temperature into heat-stable rubbery products. No special equipment or skill is needed and shrinkage on curing is low.

These rubbers are made in three grades: Cold-Cure Silastomer 9159, the heavy grade which has the consistency of builder's putty and can be moulded, milled or calendered; Cold-Cure Silastomer 9160, the medium grade which can be spread or applied by caulking gun; and Cold-Cure Silastomer 9161, the liquid form suitable for dipping, injection or impregnating.

Earth Leakage and Earth Fault Protection—I

Prevention, Indication and Protection

Protection of personnel and property against the effects of earth leakage and earth fault currents is of increasing importance in view of the extended field of use of electrical apparatus. Methods of protection which rely on fuses or over-current trips may be unsuitable for many high-current installations which are now in common use, and modern methods may need consideration. Various factors are involved, which are not always emphasized in regulations, and are not always fully realized. This review of the subject is intended to evaluate the requirements and to describe possible solutions

By J. L. WATTS

EVERY year persons are killed and injured and fires are caused due to defective electrical installations in industrial and domestic premises, and it is evident that a large proportion of these accidents are due to earth-leakage currents or earth faults, with which defects this review is concerned.

Leakage and earth-fault current

Since no insulation is perfect there is always a minute leakage current passing through, and over the surface of, insulation to which voltage is applied, although in most cases the leakage is so infinitesimal as to be of no consequence whatever. Under certain circumstances, however, leakage current may reach a value which is sufficiently high to introduce a risk of electrical shock or fire, if not properly guarded against.

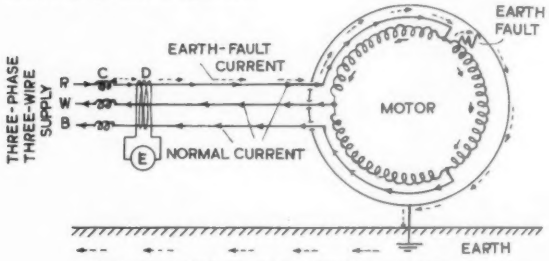


Fig. 1.—Earth-fault current in a three-phase motor circuit

An earth fault is due to breakdown of the insulation between a current-carrying conductor and earth, or conducting materials in contact with earth, such as metal casings of apparatus, metal sheathings and conduits of cables, conducting metalwork such as piping or structural steelwork, or a conducting floor in contact with earth. The resulting earth-fault current may reach a very high value which may be dangerous to life and/or property if safeguards are not taken. Protection against these risks involves the use of automatic devices to switch off the current in the event of dangerous conditions arising.

Periodical tests and inspection

It will be appreciated that careful installation work in the first place, having regard to possible faults, is an important safeguard against the possibility of dangerous earth-leakage and earth faults. However, the preventive value of periodical inspection and testing of all installations may not be fully realized.

There is little doubt that a very high percentage of earth faults are due to gradually developing deterioration of the insulation. Such defects can quite often be detected before failure occurs if the insulation resistance of the complete installation and apparatus is tested periodically,

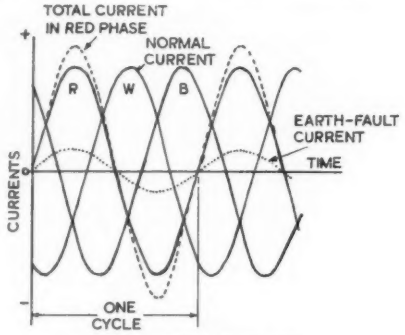


Fig. 2.—Three-phase currents

as advised or required by various regulations. It is then usually a fairly inexpensive matter to repair or renew any weak insulation which may be disclosed; often this can be done at a time when the faulty part of the installation is out of use. This procedure not only minimizes the risk of electric shock or fire, but may be the means of prolonging the useful life of an installation, and also the means of avoiding consequential losses due to breakdowns which were not anticipated.

Periodical inspections will often disclose any conducting parts or connexions which have become loose and require securing in order to avoid their making contact with other metalwork. With proper inspection and maintenance the function of the automatic earth-fault protective gear should merely be to provide safety in the event of accidents which could not be anticipated nor forestalled.

Earth-leakage indicators and recorders

Even in a well constructed installation it is, of course, possible for earth leakage to occur during intervals between periodical tests. If the exposed metalwork of the installation is properly earthed it is possible for such leakage current to reach quite a high value without resulting in fire or electric shock. However, it is most desirable that any such leakage current be detected and

the cause rectified before dangerous conditions arise or the leakage current causes frequent operation of the protective gear.

Such leakage currents may be detected by means of a suitably-connected ammeter or, better still, by an earth-leakage recorder. The principle of an earth-leakage indicator or recorder is indicated in Fig. 1. In a sound circuit the current which passes in one direction through a circuit conductor, or conductors, should return instantaneously through the other circuit conductors, or conductor. Thus the algebraic sum of the currents in the circuit should be zero. In the event of an earth fault on the circuit some of the current which flows in one direction through a circuit conductor, or conductors, will return to the supply plant through the earthing conductor, or through earth, instead of through the other circuit conductors, or conductor. The algebraic sum of the currents in the circuit conductors will then no longer be zero, and if a ring-type current transformer D encircles these conductors there will then be a resultant current in the transformer which may be applied to the leakage indicator or recorder E. The leakage current, or earth-fault current, may then be indicated in E, even though it may be insufficient to cause the excess-current release C to switch off the current. Whilst Fig. 1 shows the directions of the various currents at a particular instant in the a.c. cycle, the currents at other instants may be seen from Fig. 2.

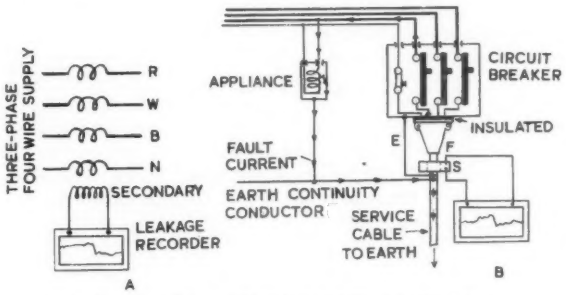


Fig. 3.—Connexions of earth leakage indicators and recorders

It is very useful to fit such a leakage indicator or recorder, which is usually connected to show the total leakage on the installation. Where the installation is fed from supply plant or a transformer situated on the consumer's premises, the leakage device may be energized from a current transformer which is connected between the neutral point of the supply and earth. However, if the exposed metalwork on the consumer's installation is bonded to the neutral point of the system, the current transformer should be connected between the exposed metalwork and the neutral point, not in the earthing conductor between the neutral point and earth.

Fig. 3a shows one method which may be used on a three-phase four-wire circuit, even when the earthed neutral point of the system is not accessible to the consumer. The leakage device is energized from the secondary winding of a current transformer having primary windings in each phase and neutral. Fig 3b shows a similar system, using a ring-type current transformer S. It is important that the secondary winding S should not be subject to the leakage current flowing through the earth-continuity conductor, as well as through the circuit conductor (s), as would be the case if the consumer's earth-continuity conductor was connected to a point on the consumer's side of the current transformer S, or some fault current passed through the earthing conductor E and lead sheathing F. This difficulty can be avoided by insulating the sheathing of the service cable from the main circuit-breaker, and connecting the earth-continuity conductor for the installation on the service side of the transformer S, as in Fig. 3b.

If earth leakage is indicated the circuit which is responsible for the leakage can be found by noting the leakage indication whilst switching off circuits in turn. The exact location of the fault can be found by means of an insulation-resistance test set applied to that particular circuit. It should be noted, however, that an earth leakage may not be fully indicated if there is also an earth fault on a neutral conductor on the consumer's installation. Consequently, periodical insulation resistance tests are advisable on the phase and neutral conductors.

Fire and shock treatment

Fire-fighting appliances should, of course, be available in various positions and should be kept in working order. Automatic fire extinguishers and fire-alarm systems may be installed if necessary. Fire extinguishers using carbon tetrachloride, carbon dioxide or chlorobromomethane are suitable for dealing with minor outbreaks of fire even before the current is cut off. The maintenance staff should be familiar with methods of treatment for electric shock, and should practise artificial respiration periodically. Instructions as to the treatment of persons subject to shock should be posted in various places where electricity is used, particularly in departments in which portable electrical appliances are in use.

Earth-fault protection and regulations

Various methods have been adopted to protect against dangerous earth-leakage currents and earth faults, as will be detailed later, and various regulations are in force. Sometimes the regulations are not fully complied with due to lack of understanding of the requirements. The same regulations do not apply in all types of industrial and non-industrial premises; and it is obvious that opinions differ as to the best methods of protection, since there are differences in the practices in various countries. It seems unlikely that finality has been reached in earth-fault protective methods, or in methods of testing the effectiveness of the protective devices. As will be seen later a protective system which may be effective for a low-current installation may be unsuitable for a high-current one.

It seems unlikely that 100% protection will ever become a practicable proposition but, nevertheless, it is desirable that the requirements be fully understood and attempts made to reduce the number of accidents for which earth faults are responsible. Due to the many variable factors involved, protection against earth-fault risks is often a more complex matter than protection against short circuits. Earth-fault protective systems can be considered from the viewpoint of effectiveness, reliability, discrimination, testing, and cost. In dealing with this rather controversial subject an attempt has been made to compare the merits and demerits of the various available methods for the guidance of persons faced with the problem of protection of property and personnel.

Further articles will deal with the protection of conductors against overheating, fault current from other systems and earthing circuits, electric shock risks, earth electrodes and protective multiple earthing of neutral, protection by fuses and overload circuit breakers, earth leakage trips, special precautions for dangerous conditions, and testing the protective system.

Ultrasonic Welding

The plasticity required for the welding of metals has hitherto been obtained by heating, which sets up high molecular vibration. The same effect can be produced by mechanically or electrically induced ultrasonic vibration, but without any great rise of temperature. The obvious advantages are the welding of dissimilar metals or sections of greatly differing thickness

THOSE who use ultrasonic means of non-destructive testing have long been familiar with the remarkable properties of ultrasonic vibrations. Ultrasonic vibration has also been used as a means of removing oil, dirt and grease from materials. Of recent date a third field of application for ultrasonics has come into being. This is ultrasonic welding, the principal advantage of which is that it can be employed to join metals either of unlike kinds or too difficult to unite by normal welding processes. Among these may be included the stainless and heat resisting steels, the high nickel copper alloys, tantalum, molybdenum, zirconium, and other metals coming increasingly into the picture as materials for parts of jet engines, missiles, etc.

First developed about five years ago, it was employed to weld exceptionally thin foils of aluminium and other metals. It is now being suggested as capable of a much wider range of application for which more powerful and efficient apparatus is being designed and manufactured.

Before the mechanical requirements of ultrasonic welding are discussed, however, we must consider the main principles of the process. First, what are ultrasonic vibrations? They are actually sound waves with frequencies so high that they are inaudible to the human ear. In practice, the frequencies used in industry range up to 20 megacycles per sec.

Ultrasonic sound waves develop vibrational energy, and this energy when delivered to a weld zone is capable of producing heat. The heat developed is not such as to produce a large increase in temperature, but it can produce a degree of plasticity in the metal to be welded. Aluminium sheets have been found to attain temperatures within the range 200° to 320° C during ultrasonic welding. Combinations of Monel metal and aluminium have been heated to temperatures in the region of 540° C. Even higher temperatures have been recorded in a 4% vanadium-titanium alloy.

In short, ultrasonic sound waves will heat metals sufficiently for welding to become possible, but it does not melt them. The increase in temperature may temporarily affect the properties of the weld metal. While to weld a hard metal requires greater power than to weld soft metals, this does not mean that soft metals are always easier to weld than hard metals. In fact, some extremely soft materials are more troublesome to weld ultrasonically than some harder qualities of the same basic metals.

Broadly, it seems to be established that the harder the metal to be welded, the narrower becomes the weld area. Conversely, the thicker the material to be welded, the greater the weld area, up to a certain point beyond which enlargement of the area becomes impracticable. This limiting point is different with different metals and different holding forces.

The use of ultrasonics for welding depended, of course, on the prior development of an efficient industrial transducer. A transducer is a method of interchanging electrical energy and mechanical motion. There are a number of basic arrangements, such as the laterally-driven reed type and the lateral-drive type, both of which introduce the vibrations by way of a welding tip. It would necessitate a considerable space to describe in detail the construction and electrical principles of the transducer and we need indicate here only that it is employed in combination with a force-insensitive mount which is designed to prevent the resonant frequency from moving with the application of power to the system, so helping to prevent loss of energy. Another item of the welding equipment is a reflector anvil to enable the vibrational energy to be concentrated within the weld. Mechanical, hydraulic or pneumatic means of applying static force to the weld, and an electronic timing mechanism to control the period of duration of the ultrasonic pulse, are also required. Lastly, a source of power and a driving unit are required. The maximum power requirement for large transducers is, up to the present time, about 6000 kW, but this figure will soon be exceeded when newer transducers come into being.

The rate of welding depends largely on the thickness and type of metal being welded. Thin sheets have been welded at their seams at a rate of about 20 ft per min using continuous welding. The voltage required so far does not exceed 220, and it is not essential that the welding plant should be immediately beside the driving gear. A distance of as much as thirty yards is permissible between them.

Turning now to the applications of this form of welding, it may be said that both intricate and uncomplicated welds can now be made. It should be noted that ultrasonic welds do not demand that both the parts to be united be of thin gauge. The advantage of ultrasonic welding lies, in fact, in the possibility of uniting a thin section to a thick one, i.e., one thick in relation to the other. This is difficult with other welding processes. With vibration welding, however, it has been found possible to join small ribs 0·25 in. in height to cylindrical rods and tubes. The ribs run helically about the rods or tubes, which are about 2 in. dia. Another possibility is the welding of thin corrugated sheet to a thicker baseplate along the roots of the corrugations, the welds being of seam type. Multiple seam-welds have been made at the rate of 20 ft per min on thin sheet of about 0·01 in. thickness.

It is naturally of importance to consider the structural condition of welds produced by this process. It has been

found by investigation that the region heated during welding undergoes a transformation to a type of microstructure typical of the high temperature state. When the weld cools, this structure is retained. The two surfaces are firmly united as a result of recrystallization and growth of the metallic interfaces.

It is also important that a good deal of structural deformation takes place as a result of ultrasonic welding, particularly if the two sheets or parts to be joined are of almost the same degree of hardness. The structural deformation at the interfaces is not reflected externally, however, and does not affect the strength and efficiency of the weld. Hence it becomes possible to unite a large number of different combinations of metals, e.g., brass to copper, steel to zirconium, platinium to molybdenum, tungsten to nickel, etc.

Among the most commonly welded materials using this process are 18-8 stainless steel, titanium alloys, Inconel nickel-copper alloy, and zirconium alloys; but numerous other bi-metals and materials have been successfully welded by the process. Its main field appears to lie, however, in the union of materials for corrosion- and heat-resistance. How far it will develop depends largely on the success of manufacturers of welding equipment in designing effective machines of greater power than those in use at present and therefore able to make welds with heavier gauges of sheet and plate metal.

Reference must be made also to ultrasonic soldering, which is carried out by means of an ultrasonic soldering iron. This is made up of a removable copper soldering bit and a magnetostriction transducer. The soldering bit, raised to the correct soldering temperature by means of a standard resistance winding, is secured to a brass block maintained firmly in contact with the nickel core of the transducer. The ultrasonic power essential for the driving of the transducer is provided by an electronic amplifier making up the power supply unit.

The soldering iron destroys for a period the refractory oxide film on the majority of light metals by ultrasonic stimulation. In consequence, a clean surface is obtained and this makes the soldering of aluminium and other metals considerably easier. In use, the soldering bit is raised to the normal operating temperature. The transducer is then energized and the bit tinned by the application of a soft solder. It is essential to maintain a good liquid contact between bit and work to make sure of the greatest possible acoustic efficiency and satisfactory welds.

We must conclude by describing some of the methods of generating ultrasonic waves. At least three kinds of apparatus can be used for this purpose. One is the siren generator, which develops ultrasonic energy by forcing air under pressure through a pair of discs provided with perforations and rotated, either singly or as a pair, at varying speeds for varying frequencies. Another is the crystal transducer or piezo-electric crystal which is energized from the output terminals of a radio-type amplifier, so that ultrasonic vibrations are developed by the swift expansion and contraction of the crystal. The third is the magnetostriction generator earlier mentioned. This develops ultrasonic vibrations by the swift expansion and contraction in ferro-magnetic rods or tubes. To achieve this the rods or tubes are placed in an electromagnetic field polarized with an electric current. In ultrasonic welding, as earlier indicated, the vibrations are introduced through a welding tip.

Hitherto, most of the practical work appears to have been in the United States, though hints have been made that the U.S.S.R., which is known to have paid great attention to ultrasonics, is experimenting with this use of high frequency sound waves and has already adopted the cleaning and inspection of metals, as well as their machining, by the same methods.

However, the widespread use of ultrasonic welding cannot be long delayed because in the development of many branches of industry such as the manufacture of jewellery, electronic and electrical equipment, etc., there is a considerable demand for a safe and effective method of uniting thin gauge materials, either similar or dissimilar, and particularly of welding those metals capable of offering high resistance to corrosion and heat.

It must be added in conclusion that a good deal still remains to be learned regarding the process, which involves a considerable number of variables; in particular the welding mechanism proper has still to be thoroughly investigated.

Control System for Small Batch Production

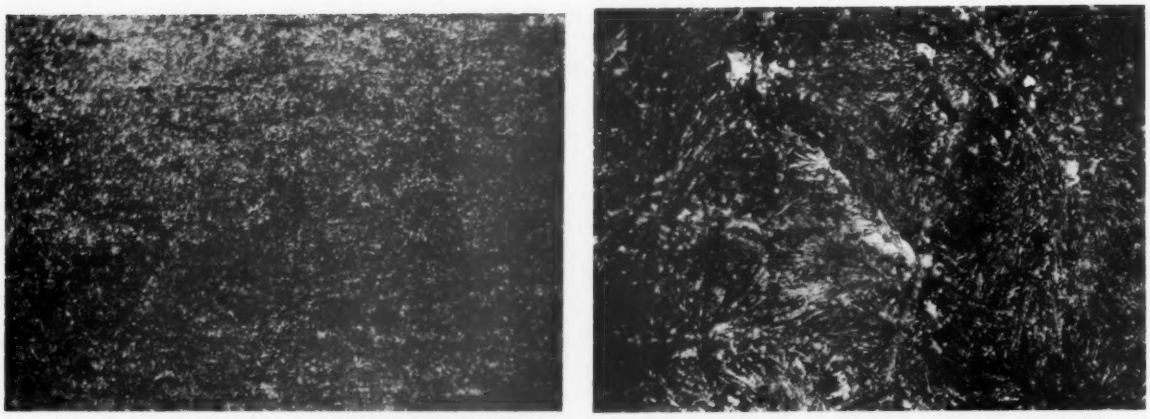
A new machine tool control system designed to meet the needs of the small batch producer, giving improved production efficiency for a small capital outlay, has been developed by E.M.I. Electronics Limited, Hayes, Middlesex. The system is fitted to a specially designed co-ordinate table which operates on recirculating ball slides and is actuated by hydraulic cylinders, for which the high pressure oil supply is derived from compressed air. The control system employs the basic principles of the other Emicon electronic positioning control systems. The fine measuring element is the Emicon general purpose inductor having an electrical accuracy of $\pm$ ·0005 in.

The control system and co-ordinate table are arranged as an integrated equipment which may be applied to a drilling machine of suitable dimensions and spindle quality. The table is automatically locked as soon as the working position is reached, and where the facility exists on the machine a signal may be provided to actuate the spindle feed when the table is in place. The machine would thus proceed automatically through a complete drilling programme.

Information can be fed into the control system in the form of five hole teleprinter tape, or alternatively may be set up on dials for manual operation. For tape control, ordinates of X and Y are read alternately from the tape using a tape reader, the output of which operates the store unit to set up the desired position analogue voltages, the machine controls, and the automatic cycling facility.

The operation of the system is as follows. The X ordinate is read and the table moves in X; the Y ordinate is read and the table moves in Y; the drilling operation is performed, and the spindle retracts after which the cycle is repeated. A green light indicates that the drilling position has been reached.

The controlled area covered is 10 in. $\times$ 10 in. on a 16 in. $\times$ 12 in. table and the electrical positional accuracy is $\pm$ ·002 in. and the repeatable accuracy $\pm$ ·001 in. The number of positions is unlimited. The power supply required is 200/250V a.c. 50 c/s and the air supply 65/100 psi.



Comparison between (at left) the fine-grain coating formed by the O.S. solution and (at right) the relatively coarse coating from a typical hot solution (×150)

Cold Phosphating

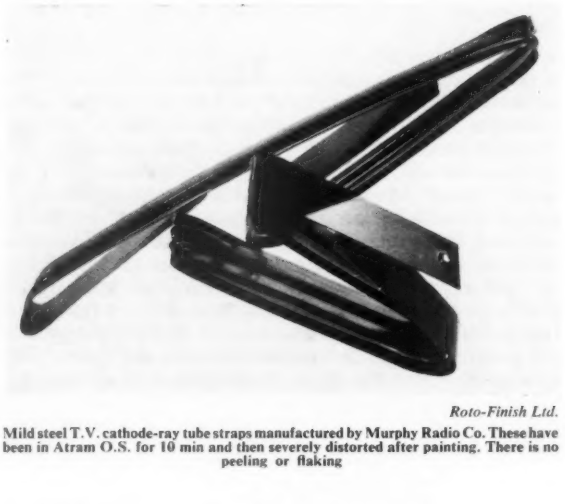
Two of the most important objectives of both manufacturers and users of phosphating solutions have been realized in a formula recently introduced to Britain from the Farbewerke Hoechst A.G. chemical company in Germany by Roto-Finish Limited. These solutions which function at room temperature and which do not progressively decompose to form sludge, are a very promising addition to the Atrament range of phosphating solutions—Atram O.S.

PHOSPHATING solutions are dilute solutions of metal phosphates—zinc, manganese or iron usually, with a slight excess of acid and certain chemicals added to accelerate the chemical reactions. They react with the surface of certain metals to produce a thin film of insoluble metal phosphate crystals which is chemically bonded to the metal and therefore very firmly adherent. These find application principally for paint bonding but to an increasing extent in this country as aids to lubrication in cold forming; other uses are as an anti-scuffing surface treatment and, when impregnated, as a protective finish. Hitherto the reactions have only proceeded at acceptable speeds when the solutions have been used hot—often nearly boiling. An inevitable concomitant of using hot phosphating solutions, however, is their gradual decomposition by oxidation, and the resulting formation of sludge.

Sludge presents several disadvantages in production: the loss of chemicals is one; its tendency to become incorporated in the coating is another; while a third is concerned with the way in which it hardens to scale and fouls the plant. Salts, and relatively costly ones too since they bear a proprietary charge, will inevitably be lost by oxidation, but a secondary and often greater loss of solution occurs if the sludge is removed, as is normal practice, by decantation of the clear solution after settling. Again, if used as an immersion process an allowance of a foot or so on the maximum working solution depth must be made to prevent the work from churning up the light, flocculent precipitate.

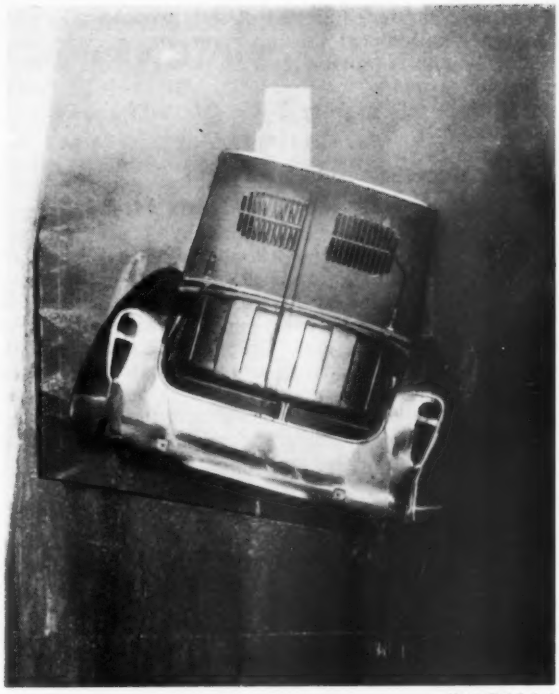
Nonetheless, some will always be in suspension and this becomes incorporated in the coating to some extent, with two adverse consequences; one is that it appreciably roughens the phosphate film, this being particularly undesirable if the coating is used as an undercoat for a decorative paint finish; the other is that it increases the porosity, and reduces the corrosion resistance of the coating.

Probably most annoying of all, however, is the tendency of the sludge to compress into a hard, insulating scale under certain conditions—notably when it settles on hot surfaces such as heating coils, and in spray nozzles when being spray-applied. Plant for hot phosphating must therefore be designed for rapid dismantling if it is to be kept operating at peak efficiency. One obvious expedient is to maintain the solution free from sludge by filtration, but the quantities of sludge formed are markedly greater than those encountered, for instance, in electroplating, and necessitate the type of filter used in



Roto-Finish Ltd.

Mild steel T.V. cathode-ray tube straps manufactured by Murphy Radio Co. These have been in Atram O.S. for 10 min and then severely distorted after painting. There is no peeling or flaking



Roto-Finish Ltd.

The body of the Prince car being cold-phosphated in an automatic pre-treatment tunnel at the N.S.U. factory in Germany

chemical manufacture; in America use has been made of centrifugal separation which although effective is inordinately expensive on a large scale.

Attempts have previously been made to market a solution which, by operating at room temperature would eliminate heating and steam extraction costs, and sludge formation. Until the appearance of the O.S. solution, however, none has produced coatings comparable with those from hot solutions. The Atram O.S. solution, operable between 10° and 30° C, produces a coating of adequate thickness both for paint bonding and to facilitate cold working operations. This is normally between 90 and 280 mgm per sq ft in weight which, though thin (about 1 micron), is unusually corrosion resistant due to its extremely fine crystal size by reducing the size of crystals the porosity is greatly lessened. Indeed, recent independent tests by one company indicated a marked superiority to hot solutions in respect of corrosion resistance, while it has lately been rated Class III by the M.o.S. Inspectorate of Armaments in accordance with the Inter-Services Defence Specification D.E.F.-29.

The solution is a relatively complex and highly accelerated one based on iron phosphate and oxalates, and used at 3·5% concentration. Treatment times are from 5 to 10 min immersion (unagitated) and 1 to 5 min spray application. One manufacturer is using a combination treatment involving spraying of steel at high pressure, ca. 55 psi, whilst it is immersed in the solution; in this way a very uniform and corrosion resisting coating of 160 mgm per sq ft is built up in 3 min. Solution control calls only for an acidity titration, which can, if desired, be made by the operator.

As with other phosphating processes the work requires the correct preparation prior to treatment, this usually

Roto-Finish Ltd.

Frames for water scooters being spray phosphated with O.S. solution at the N.S.U. works

comprising degreasing in a solvent, emulsion or suitably inhibited alkali cleaner; rust or tarnish is most advisedly removed too, to avoid unduly contaminating the phosphating bath, although this will dissolve light films. Post-treatment operations include a second stage which is actually an integral part of the process. This consists of a brief immersion in the O.S. 'after-treatment', a solution of chromates and phosphates of 0·7 to 1·0% strength, also used at room temperature. This serves to 'fix' and to enhance further the corrosion resistance; it is controlled chemically or by pH tests. Finally the metal is rinsed in hot weak chromic acid and dried off.

In its simplest form, then, the cold phosphating process needs only two unheated mild steel (preferably rubber-lined for the O.S. solution) tanks, with ancillary provision for cleaning, swilling, etc. Its sterling qualities are no less apparent when it is used in automatic machines. Its chief application is as a paint bonding preparatory treatment for ferrous metals, but is equally applicable in this capacity to zinc. Of especial note here is the extremely sound adhesion and flexibility of the coating which, used in conjunction with high grade paints, gives a finish which can be considerably deformed without detriment, Fig. 5, and will regularly give Erichsen cupping test values of 9 mm. Again, in metalworking there is the convenience of using a cold solution for phosphating steel prior to cold drawing or extrusion. The coating thus formed both provides a remarkably adherent and fully stable parting layer which prevents metal-to-metal contact even under the extremely high pressures here encountered, while it also absorbs and retains conventional lubricants.

Portable Industrial Buildings

A new portable building marketed under the name "Swiftplan" is architecturally designed on a 24 ft × 8 ft grid with panels 3 ft and 5 ft wide to give variety of elevation and flexibility of planning. Stressed skin roofs and floors are features incorporated in construction and site work is cut to a minimum by having glazing, painting,

wiring for lighting and linoleum floor covering all carried out in the factory. Heating can be electric or other approved conventional methods according to customer's requirements.

A complete building of four units (800 ft super) comprises one load, each unit being provided with lifting attachments for off-loading by crane on to prepared footings. Where toilet or kitchen blocks are required, these are despatched from the factory fully erected and complete with all services to be similarly handled by crane.

Speed of erection, flexibility of use as offices, etc., combined with a high recovery value and a first-class service for movement or modification, makes this new building a satisfactory answer to many accommodation problems. It is made by Swiftplan Limited, 39 Victoria Street, London SW1.

Miniaturized Machine Time Control

For the operation of machine tools and equipment according to predetermined sequences and time intervals, the Electrical Remote Control Company Limited, of The Fairway, Bush Fair, Harlow, Essex, have introduced a miniature timer, the two-cam model, for example, measuring only $2\frac{3}{4}$ in. × $3\frac{1}{2}$ in. × $6\frac{1}{2}$ in. The time setting dials with their associated cams are simply rotated by hand to make adjustment, and a solenoid-operated clutch gives complete disengagement of the timing members during resetting. Resetting can be automatic at the end of a time sequence, or cycles can be repeated continuously with automatic resetting on power failure or shutting down. Standard time ranges are 0–30 and 0–60 sec, 0–5, 0–10, 0–30, 0–60 min, 0–4, 0–12, 0–24 and 0–48 hr.

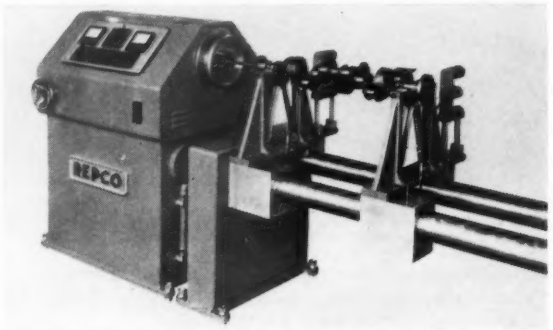
The timer type AMS is supplied with 1, 2 or 3 change-over switches. Each of the switches is associated with a continuously adjustable cam which has the effective length of cutout variable by turning of the calibrated dials attached to each half cam. On reset all the change-over switches are returned instantly to de-energized position before the switch operating cams are returned automatically to zero position within half a second. If the clutch coil is wired into one of the timed circuits of the timer, the timer will reset automatically at the point to which this circuit has been preset. When the electro-magnetic clutch is connected directly to voltage supply the timer will repeat its maximum timing cycle continuously with automatic reset on power failure or shut down only.

The timer sells at from £7-15s.-0d. to £9-13s.-0d.

Two-cam miniature timer with automatic resetting

Balancing Machines with Electronic Detectors

New types of machine developed by Repco Limited, Dundas House, St. James's Street, London SW1, have patented electronic vibration detectors and cathode ray tubes which combine sensitivity with ease in locating the points of unbalance. The example shown in the illustration is in use at Jack Brabham Motors Limited, Chessington, Surrey, and in it a crankshaft is spun in a bearing at either end, and is driven through a flexible coupling. Each bearing is carried on a light aluminium support, this in turn being attached to the machine by flexures providing easy, undamped movement.



Repco small electronic balancing machine set up for rapid balancing of a crankshaft

Both bearing supports are connected by light rods to magnetic pick-ups which convert vibratory movement into electrical impulses. These are amplified electronically and fed into a cathode ray tube, which indicates by the circular trace produced, the source of vibration. A meter indicates its magnitude, and thus the amount and location of metal to be removed from the counterweights to correct the unbalance is known.

In practice, the circular trace, which is one of the patented features makes the determination so simple that tests are quickly made even by operators with no special training, yet the sensitivity is such that a displacement of 0·000025 in. due to vibration is measured, which is equivalent to unbalance within 0·002 oz-in. per 10 lb of rotor weight.

Standard machines have motors variable in speed between 400 and 4000 rpm, while others have three speeds of 650, 1100 and 2200 rpm. They can take rotors up to 200 lb. Special machines are designed for rotors varying from a few ounces to several tons.

Simpler machines for balancing in only one plane are used for disc-like structures such as clutch plates. These utilize a stroboscopic light to locate the heavy point and are usually constructed with a vertical drive shaft.

The same principle is used in the Replex electronic wheel balancer for balancing dynamically the complete road wheel and brake drum assembly without removing the wheel from the vehicle.

Treatment Plant Returns Water for Re-use

A good deal of water is required in the course of finishing motor car bodies. Mains water is not the best for the purpose because of the dissolved solids deposited when the water dries off. At the Ford works at Dagenham some 25,000 gallons are required hourly, and in addition to the suitability of the water there has recently been a threat of restriction in supply as well as the problem created by increased charges.

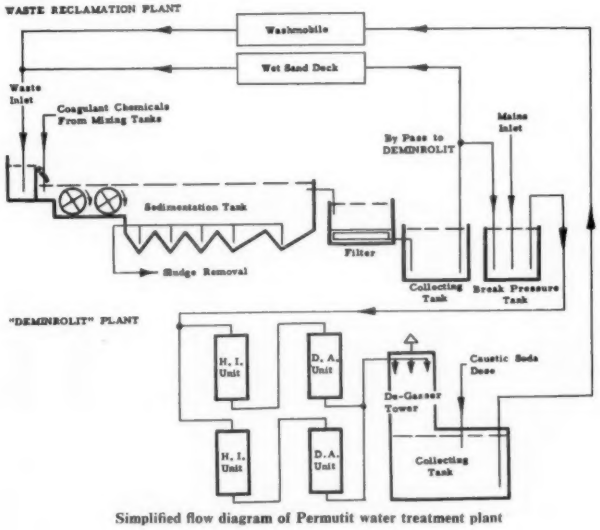
All these difficulties have been overcome by a water recovery plant supplied and specially designed for the purpose by The Permutit Company Limited, of London.

The scheme is embodied in a comprehensive plant which is illustrated diagrammatically in the accompanying sketch. This plant—arranged in two sections—recovers the waste water from the paint spray "Washmobile" section and wet sand deck, purifies it and recirculates it for re-use; at the same time it produces demineralized water for the Washmobile. Normal output from the plant is 23,000 gph of purified, reclaimed waste water and 6,300 gph of demineralized water.

Waste water reclamation involves a process of chemical treatment, flocculation, sedimentation and filtration which removes suspended solids from the recovered water and destroys harmful bacteria. Waste water from the paint spray Washmobile and wet sand deck is collected by a drain system and delivered to a tank from where it flows over a weir and is dosed with lime suspension and a mixture of chlorine and ferrous sulphate. These chemicals sterilize the contaminated water and interact to form ferric hydroxide—a floc forming substance which coagulates suspended solids. Coagulation is assisted by two paddle wheels which agitate the flocculated water as it flows through a channel into sedimentation tanks. Here the heavier coagulated solids settle as sludge which is removed periodically from the bottom of the tanks and discharged to drain. Partially clarified and settled water collects at the top and flows to rapid gravity sand filters where residual suspended solids are removed. The filtrate is then recirculated for re-use by the wet sand deck, a proportion being by-passed through the "Deminrolit" plant *en route* to the Washmobile.

The by-passed filtrate is blended with mains water in a break pressure tank. The mains water is introduced at this point for convenience and to make up losses resulting from periodical sludge removal and filter washing in the waste reclamation plant. The blended water flows through a two-stage Deminrolit plant comprising a pair of hydrogen-ion cation exchange units and a pair of "De-Acidite" anion exchange units. These units are arranged as pairs in parallel and the water flows first through the H.I. units and then through the De-Acidite units. In the H.I. units dissolved salts are converted to their corresponding acids which are then absorbed as the water passes through the De-Acidite units. Carbondioxide is liberated by the breakdown of the dissolved bicarbonate salts in the H.I. units. This is removed in a degassing tower where the water falls through an upstream of blown air which picks up the CO_2 and vents it to atmosphere. The de-gassed water collects in a tank at the base of the tower where it is dosed with a small quantity of dilute caustic soda solution. This neutralizes residual CO_2 and maintains correct pH conditions.

Treatment completed, the demineralized water is pumped to the paint spray Washmobile via a reserve storage tank.



Simplified flow diagram of Permutit water treatment plant

Workshopping Trolley

Introduced by Tool Treatments (Chemicals) Limited of Colliery Road, Birmingham Road, West Bromwich, the new "Mini-Bogie" presents a quick, easy and economical method of man-handling a wide range of commodities within factories. The large high density rigid polythene container size 18 in. × 15 in. × 13½ in. is mounted on an ingenious transporter that can be easily pulled along the straight or swivelled round on its own axis to negotiate the most awkward spaces. The bin is robust and quite suitable for use as a transporter for such items as nuts and bolts and other small engineering component parts. The price of the bogie is £4 18s. 6d. and that of the container 75/-.

The "Mini-Bogie" workshop trolley with free swivelling pivot

Induction Hardening Practice

Originally developed for the melting of metals, high frequency induction heating shows considerable advantages when applied to the heat treatment of steel. In this article the basic principles are first discussed and then it is shown how particular characteristics can be very effectively applied to certain classes of hardening operations

By A. G. GARDNER, A.I.M.

IN general terms, the advantages of induction heating can be listed as follows:—

(1) Increased heating speed with consequent increase in output and reduction in labour costs
(2) Localization of heat to a restricted area, thus reducing operating costs
(3) Improved and consistent quality of product
(4) Results can be obtained which are not possible by other means.

Fundamental considerations

When a coil is connected across the output terminals of a high frequency generator, a considerable current flows in the coil and produces an alternating magnetic field. This coil, in induction heating, is known as the heating coil from its effect on a metal object placed within it. The heating coil may be regarded as the primary of a transformer and sets up a magnetic flux. This energises the metal workpiece (or "secondary" of the transformer) so that a current flows around its surface. In overcoming the resistance of the metal an energy loss occurs. The loss appears as heat generated in the material of the object, and high heating rates can be obtained by this means. The heat generated is proportional to the power being transmitted and occurs mainly as a result of the electrical resistance of the work being heated to the passage of the currents induced in it, i.e. it is a simple I^2R resistance heating effect. By the suitable choice of frequency, power and time, the heating effect can be either confined to the skin of the material to a desired depth or allowed to penetrate to the centre. The process can, therefore, be applied either to surface hardening heat treatable steel, when the heating is followed by quenching, or to through heating for deep hardening.

The strength of the magnetic flux also varies inversely as the square of the coupling; the coupling is the gap between the inside of the coil and the surface of the work. By varying the degree of coupling the heating rate can be controlled; close coupling gives a fast heating rate. The relationship between coupling and depth of heat penetration is illustrated in Figure 1. Close coupling results in fast heating with shallow penetration, and as the coupling becomes looser the rate of heating is decreased and the heat penetration is deeper. Work should generally be placed within the coil since the density of the flux is greater within the coil than at the outside where eddy current loops are not completed.

Factors influencing heating rate

These may be summarised as follows:—

(1) Power output of high frequency generator
(2) Frequency employed
(3) Design and position of heating coil
(4) Resistivity of workpiece.

These items will now be dealt with in turn.

(1) Power output of high frequency generator

The power required for induction heating may be calculated fairly accurately from the following equations. The first step is to determine the heat required in British Thermal Units.

$$\text{Btu} = S \times W \times \Delta T \times A \quad \ldots\ldots(1)$$

where S = Specific heat of material to be heated
W = Weight of material, lb
ΔT = Temperature rise required
A = Factor which allows for losses.

Losses may occur as a result of heat conduction and radiation; also as a consequence of coil coupling. The coupling cannot be made so close as to cause arcing between coil and work; sufficient clearance must be provided. A value around 1·75 for A should provide a suitable allowance factor.

Now the heat required to raise 1 lb of water through 1° F is one Btu. The coefficient of specific heat of a material is the number of Btu required to raise 1 lb of the material one degree F. Water, therefore, becomes a standard with a specific heat of 1.0.

Using equation (1) we are now in a position to work out an example. Suppose a piece of steel 2 lb in weight with a specific heat of 0·15 has to be heated to 1,500° F, using a loss factor of 1·75. If the room temperature is 60° F, then the temperature rise required is 1500—60= 1440° F. Hence, substituting the appropriate values in equation (1) we have:—

$$0{\cdot}15 \times 2{\cdot}0 \times 1440 \times 1{\cdot}75 = 756 \text{ Btu}$$

There are approximately 3300 Btu per kilowatt hour and if it is required to reach the temperature in one minute then:—

$$\text{kilowatts} = 756 \times 60/3300 = 13{\cdot}75$$

Calculations of this type are useful in deciding initially what size of generator is required for a certain application. When a generator of a particular power is available, then the above equation can be employed to work out

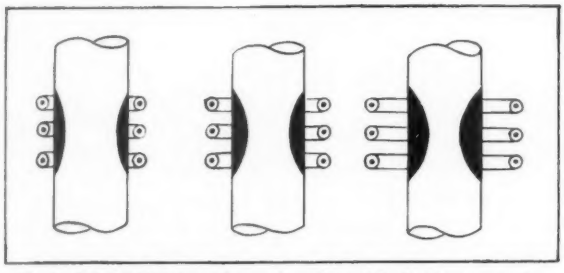
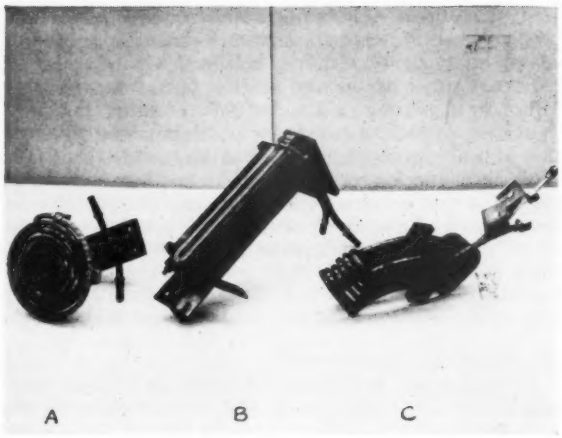


Fig. 1.—Relationship between degree of coupling and depth of heat penetration



Birlec-Efco (Melting) Ltd

Fig. 2.—Typical coils for induction heating

the time taken to bring a piece of steel to the required temperature. Continued application of power causes an increase in depth of heating for, as each layer of metal is brought to temperature, the current density shifts to the layer beneath which offers a lower resistance. Additional depth results from heat by conduction with longer time of heating.

(2) Effect of frequency

A peculiar but important property of alternating current is its tendency to concentrate in the outer surfaces of a conductor. This effect becomes more pronounced as the frequency increases, until at radio frequencies the current is concentrated into a thin skin at the surface. This is known as "skin effect". The depth of penetration is inversely proportional to the square root of the frequency. It is also related to the electrical and magnetic properties of the steel to be heated, being proportional to the square root of the resistivity and inversely proportional to the square root of the permeability. Since resistivity increases and permeability decreases with temperature rise, the depth of penetration becomes greater. The effect of the magnetic properties is, however, quite small in relation to the resistivity of the material being heated, and there is a very simple formula for calculating the approximate depth of penetration of electrical energy. The equation is:—

$$D = \sqrt{4/F} \quad \ldots\ldots (2)$$

Where D is the depth of penetration in inches, and F is the frequency in cycles per second. The depth of heat penetration is always in excess of current penetration because during the heating period, no matter how short, heat is penetrating to lower depths by thermal conduction.

Where deep penetration is required, frequencies of 2000–10000 cycles per second are used. Where surface heating only is required, a frequency range of 200,000–500,000 cps is employed. Extremely thin layers may be heated by frequencies of the order of 1 megacycle (1,000,000 cycles) per second or more.

(3) Design and position of heating coils

Induction heating coils are invariably made of high-conductivity copper in order to obtain the greatest density of current for a given potential. Heating coils are made in a wide variety of shapes which depend upon the particular applications. The most generally used type is either a single or multi-turn design formed from copper tubing to suit the shape of the part. It is nearly always necessary to provide cooling for the coil and this is most easily carried out by circulating water through the coil itself.

Some high-frequency generators are limited to certain specific types of coils which will match their output impedance. Other generators are provided with means to match the impedance of practically any type of heating coil thus making possible a wider choice of coil designs.

The heat pattern produced in the workpiece will closely resemble the shape of coil, especially where there is a close coupling between work and coil, and this type of coupling gives maximum heat transfer.

The range of coils, or inductors as they are alternatively called, is extremely wide, typical examples made by Birlec-Efco Limited being shown in Fig. 2. Basically, however, coils may be divided into three classes as follows:

(i) Helical inductors, single and multi-turn, internal and external
(ii) Channel-type inductors for continuous through heating
(iii) Surface heating inductors either pancake or iron cored.

Referring to Fig. 2, A shows a pancake-type coil for heating flat surfaces. It tends to leave the centre unheated and has largely been replaced by iron-cored inductors B. The inductor shown at C is a channel type for heating the ends of bolt blanks. D is a single turn coil, split type with self-contained quench for hardening the pin and main journals of crankshafts. E is a single and F a multiturn helical inductor. G is a surface heating inductor without iron core, for heating the treads of track rollers, the flanges of which prevent the use of a helical coil. H is a small single-turn inductor for the progressive hardening of track pins. J is another type of single-turn inductor.

All of the above coils, except C and F, have similar "fishtails" for bolting to the H.F. output terminals, and are, therefore, readily interchangeable.

Helical inductors.—The simplest form of inductor in which a helical coil of one or more turns is used. Multi-turn coils are generally employed for through heating and single-turn coils for surface hardening. Both types can be used for single shot (stationary) or progressive (continuous or intermittent) heating. Usually the part to be treated is passed through the axis of the coil (external

heating), but the coil may be passed through the part (internal heating).

Inductors, as previously mentioned, are usually water cooled and precautions should be taken to prevent furring up of the bore due to the use of hard water.

Channel inductors.—In many applications of continuous heating it is necessary to support the part (on a conveyor or turntable) during its passage through the heating coil. The channel type of inductor is useful in such cases, particularly when only one end of a bar or tube is to be heated. The coil comprises a group of conductors on either side of the workpiece with cross connections kept out of the line of motion.

Surface heating indicators.—Iron-cored coils are now generally used for the heating of plane surfaces. Originally a pancake coil, consisting of a flat spiral, was used, but was found to give unsatisfactory results due to the tendency of the induced currents to flow around the periphery of the part to be heated, leaving the centre unheated. By the use of laminations it is possible to concentrate the flux in any required pattern.

The simplest form of iron-cored inductor consists of a single turn, in the form of an elongated loop or hairpin, surrounded by iron laminations. The inductor may extend the full width of the plane surface so that by passing the surface under the inductor at predetermined speed the whole area is heated.

Heating rate.—The heating rate provided by a coil is influenced by its shape in the following manner. A cylindrical coil provides a fast heating rate at the surface of parts placed inside it. The flat or pancake coil gives a somewhat slower heating rate per square inch of area which would probably be about three-quarters that of the cylindrical coil. Internal coils give an even slower heating rate since less magnetic flux is concentrated on the work surface. The rate would be only about a third that of a cylindrical coil. The greatest strength of magnetic flux lies next to the inside surface of an inductor coil and for this reason the overall distance from the inner surface of the object being heated to the inner surface of an internal coil should be kept to the minimum. In this connexion, flattening of the coil can be of assistance.

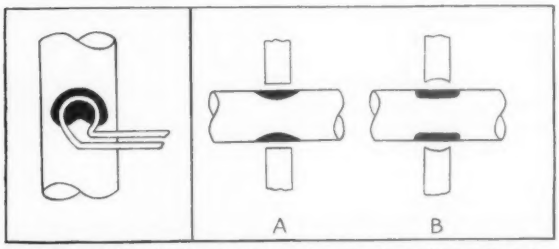


Fig. 3 (extreme left).—Heating a localized area by means of a small loop coil. Fig. 4.—A and B. Modification of single turn coil to obtain even heat penetration

Distribution of heat.—A property of high frequency heating is that the path taken by the current on the surface of the work will follow the form of the coil. The current has to complete loops in the work and this means that the coil must be in the form of a loop around or adjacent to the areas it is required to heat. A localized area can be heated by means of a small loop coil as shown in Fig. 3.

When a shaft or rod is heated with a single turn coil as shown in Fig. 4A, the depth of penetration is not even, but this may be corrected by making the coil concaved slightly as shown in Fig. 4B.

Similar effects are obtained with multiple-turn coils, i.e. the depth of heat penetration is greater opposite the centre of the coil as shown in Fig. 5A. This may be corrected either by making the coil turns concave (Fig. 5B) or by increasing the spacing between turns (Fig. 5C).

In spite of these methods for obtaining even distribution of heat in rods or shafts, there is a limit to the length of surface which can be heated at one time and it is suggested that a helical coil should not exceed three to four times its diameter. When a greater length is required to be heated it is usually better progressively to feed the work through a relatively short coil. This also means that a generator of less power is required as compared with heating the whole part at one time ("one shot" heating).

(4) Resistivity of workpiece

Heating of the workpiece is achieved by certain losses which cause the temperature to rise. In magnetic materials with which we are concerned in the case of steel, these losses arise from two sources: eddy currents and hysteresis. Eddy currents consisting of small circulating currents within the material are the chief heating effect. These currents are caused by potential differences at various points in the material as a result of the alternating magnetic field which cuts the work. Eddy current losses are proportional to the square of the current and to the electrical resistance of the material being heated,

$$\text{i.e.} \quad W = I^2R$$

This loss is proportional to the square of the frequency and field strength.

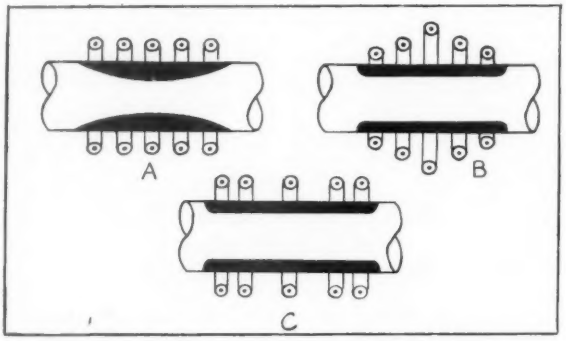


Fig. 5.—Modification of multiturn coils to obtain even heat penetration

Hysteresis losses occur only with magnetic materials and are probably due to molecules acting as small magnets vibrating with the frequency of the alternating magnetic field. Heat energy is generated as a result of friction between adjacent molecules. This heat energy known as hysteresis loss is directly proportional to the frequency of the magnetic field and to the magnetic field strength.

Hysteresis losses decrease with temperature and cease altogether when the curie point temperature has been exceeded. In any case hysteresis losses are relatively small as compared with eddy current losses at frequencies used for induction heating.

Practical application of induction heating to hardening of steel

In the field of hardening there are two main classes of work to which induction heating can be applied. These are through hardening and surface or local hardening.

The former has received limited application so far, but the latter has been widely applied in this country, particularly in motor car and other light industries employing mass production.

Through hardening

Large sections can be heated through more economically in a conventional type of furnace, but induction heating offers advantages in the treatment of small parts where its speed, inherent cleanliness and precise control are desired and in cases where localised annealing or tempering is required.

As an example, an installation for through hardening of bar stock between $\frac{1}{2}$ in. and $1\frac{1}{2}$ in. dia uses two coils. A $2\frac{1}{4}$ in. bore coil is employed for $\frac{13}{16} - 1\frac{1}{2}$ in. dia bar and a $1\frac{1}{4}$ in. bore coil for $\frac{1}{2} - \frac{3}{4}$ in. dia bar. The same coils are used for both hardening and subsequent tempering. Bars are rotated during treatment to prevent distortion. A very high degree of uniformity can be achieved by this kind of induction treatment. Power in the example quoted was supplied at 10 kc/s from a 100 kW alternator driven by a 180 hp motor. Hardening speeds of 28 in. per min for $1\frac{1}{2}$ in. dia shafts and 56 in. per min for $\frac{3}{4}$ in. dia shafts are achieved with this set-up. Tempering speeds are slightly lower than for hardening and coil power input is considerably lower.

Through heating has also been applied to the localized annealing of clock springs. A heating time of only 0·25 sec was required when using a $2\frac{1}{2}$ kW valve oscillator generator. The output was 60 springs/min.

Surface or local hardening

Here the "skin effect" of high frequency currents is exploited in order to raise the temperature of the surface layers. The parts are subsequently quenched to give a hard surface. The advantage of being able to treat selected zones of a workpiece merely by the shape and size of heating coil, and without recourse to such time-wasting devices as "blanking-off" is of the greatest importance. In addition to such advantages as cleanliness and flexibility, the method shows two further factors of great importance in surface hardening. The first is that by virtue of the speed with which the process is carried out, scaling can be eliminated. Speed of heating also ensures a fine grain structure as there is insufficient time for grain growth. The second factor is that on account of the "skin effect", the heat is concentrated just where it is required, i.e. on the surface, providing the most efficient application of the power and a ready control of the depth of hardened skin produced. This control is carried out by careful adjustment of the speed of heating, since with longer heating times more heat is conducted from the surface where it is generated towards the centre of the piece, and a deeper layer is brought up to the required hardening temperature.

Since the core of the metal remains relatively cool throughout the whole hardening operation, distortion of the component is usually negligible so that subsequent lapping can be much reduced, or often eliminated entirely, and all machining of the part can be completed in the soft condition.

The process is applicable to carburized parts but is principally used in conjunction with plain carbon steels containing between 0·35 and 0·6% carbon.

Practical considerations

The diameter of the stock must be sufficient to offer a reasonable core since, for example, material of less than $\frac{1}{8}$ in. diameter cannot be surface hardened regardless of the frequency used.

It should also be noted that there is a minimum diameter for through heating since the induced currents tend to cancel each other out below a certain value. Recommendations by Birlec-Efco Limited are given in Table I.

Table I.—RELATIONSHIP BETWEEN FREQUENCY AND HARDNESS DEPTH

Frequency cycles per second	Minimum depth of hardness	Minimum dia surface hardening	Minimum dia through hardening
	in.	in.	in.
3,000	0·060	1·25	0·75
10,000	0·040	0·75	0·40
500,000	0·020	0·25	0·13
2,000,000	0·010	0·25	0·10

Full advantage of the skin effect of high frequency can only be obtained if the surface area can be brought up to hardening temperature in a few seconds, otherwise thermal conduction will have produced too great an increase in the depth of hardness. No method other than induction heating can supply energy at the required rate for obtaining such small depths of hardness. These high power densities can be obtained in one of two ways, firstly, by single-shot hardening and secondly by progressive hardening. Single-shot hardening means that the entire surface to be hardened is subjected to the action of a heating coil at one time. This requires a generator with a relatively great output power. Progressive hardening, on the other hand, means that the surface to be hardened is gradually fed through the heating coil so that one small area is treated at a time. This results in a much smaller power input per unit of surface area and makes possible the use of a high-frequency of lower output power.

Quenching methods

Induction hardening can be applied to a wide variety of steels including air-hardening types and those requiring quenching in such media as oil, brine, etc. Steels which require a quench treatment can either receive this by means of spray from a ring or nozzle or through the heating coil itself. Alternatively, the parts may be dropped or lowered into the quench tank after heating.

Many parts suitable for the induction hardening process can be spray-quenched. On a production set-up it is usual for a multi-stage timer to control the sequence of operations. It is then only necessary to place the work in position and often even this is done automatically. Naturally, when setting up a new application it is necessary to first of all determine the heating and quenching times manually, before arranging the repetitive sequence of subsequent operations.

The spray quench may be conveniently controlled by means of a solenoid valve which is opened for a specified time immediately following the heating operation. The arrangement should include a valve for regulating the volume and pressure of the quenching medium. The latter should be evenly distributed around the heating area with sufficient force to keep the surface well covered with spray. The volume and duration of the quench should be adequate to cover the entire heated area without applying too much pressure or force.

In some cases where multi-turn coils are used, the spray quench rings can be arranged so that the spray passes through the coil spacings. When this set-up is used it is recommended that the coil should be coated with insulating or silicone varnish in order to prevent

arcing between turns due to water remaining in the coil. Fig. 6 shows how this method can be applied to a single-turn inductor. This surrounds the part and has quench holes on the inside. The inductor cooling circuit is not shown. The inductor is shaped and dimensioned to give the correct hardness contour and depth and is provided with H.F. current. Heating and quenching times are automatically controlled as previously described.

An immersion quench can be arranged by placing the part to be hardened in the heating coil where it rests on a plate. After the heating cycle has been completed, a solenoid withdraws the plate and the work drops into the quenching medium situated below. This example is but one of the many methods which can be employed for immersion quenching. Some can be made semi-automatic whilst others are best carried out manually. Parts can be suspended in an inductor by electro magnets and then released after a specified heating period.

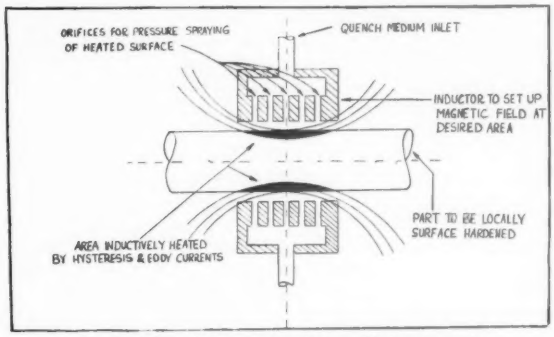

ORIFICES FOR PRESSURE SPRAYING OF HEATED SURFACE
QUENCH MEDIUM INLET
INDUCTOR TO SET UP MAGNETIC FIELD AT DESIRED AREA
PART TO BE LOCALLY SURFACE HARDENED
AREA INDUCTIVELY HEATED BY HYSTERESIS & EDDY CURRENTS

Fig. 6.—Schematic diagram of an inductor block and quench

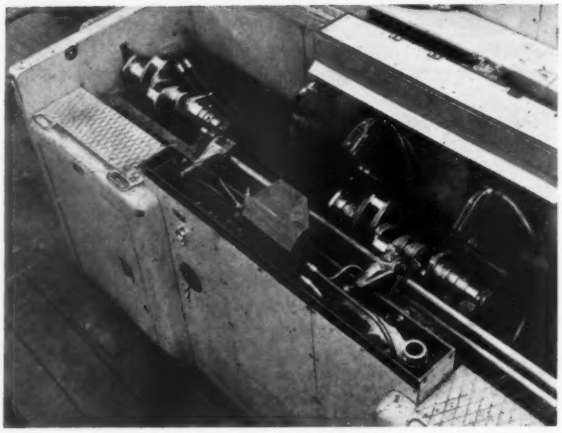
Electromagnetically operated mechanisms may also be used in conjunction with automatic timers for determining the heating period.

After parts have been dropped into the quenching medium they may be removed by means of a wire basket. A more convenient arrangement for more bulky parts is to use a conveyor. One end of this passes through the tank of quenching liquid and the parts fall through the liquid on to the conveyor and are removed.

As previously mentioned, the high power densities required for surface hardening may be attained in one of two ways. When the area to be treated is not too large a single-shot hardening technique can be used. For larger surface areas the part can be progressively fed through the induction coil. It should be noted that the use of oil quench is restricted to single-shot hardening, as an oil spray quench, as required for progressive hardening, is liable to catch fire. Some examples of surface hardening by single-shot and progressive hardening will now be described.

Single-shot hardening: crankshafts

An important example of this method is the surface hardening of the bearing surfaces of crankshafts and cam shafts using a single turn split inductor. The two halves of the coil are hinged so that it may be opened, the work inserted, and then closed, making the required electrical contact. Each half is hollow with the internal surface perforated so that, at the completion of the heating cycle, the automatic switching equipment will bring the quenching medium into the coil and spray it on the work. This



F. Perkins Ltd., Peterborough

Fig. 7.—Birlec-Efco crankshaft hardening machine

principle has been used in a machine where a four-cylinder shaft can be fully hardened in all journals—mains and pins—at a rate of 20 shafts per hour. The shaft is held in a trolley on which it is traversed to align the journals with the inductor position. The inductors, of which a number are provided to suit the journal sizes, are mounted on a common carriage arranged so that any one can be connected to the H.F. power terminals; hydraulic clamping mechanism is provided for this purpose with fool-proof indexing facilities. This machine is illustrated in Fig. 7 and the view shows the crankshaft trolley and inductor assembly with automatic discharge mechanism.

Progressive hardening

This method is applied to comparatively long parts, such as shafts, guide rods, etc., which would require too great a power input to be economically hardened by the single-shot process. Only a small area of the part is heated at one time as it is fed through a heating coil followed by a spray quench or into an immersion tank. This technique means that an H.F. generator of only limited power need be used and that far less distortion results than by simultaneous all-over treatment. A more uniform hardness is achieved since better electrical loading characteristics result from progressively heating a small area.

Induction hardening of gear teeth

Gears are used in a very wide field of mechanical equipment which includes cars, machine tools and aircraft. The increasingly severe duties which gears are called upon to perform require heat treatment techniques which by conventional methods might seriously increase production costs.

High frequency induction heating offers attractive possibilities in the field of gear heat treatment, particularly when high production rates are required. It can very greatly reduce expensive grinding and similar finishing operations which are often required to correct the distortion and scaling which may occur in furnace heat treatment practice.

Present design trends demand increasing tooth loading on gears and higher surface hardness on the tooth flanks to avoid scuffing. At the same time, the teeth must have sufficient strength to resist heavy shear and bending loads and these in many applications may be imposed under

shock conditions. The body of the gear should, therefore, have a tough, shock-resistant character combined with high surface hardness on the tooth flanks. Although the former is mainly affected by forging technique, the latter is largely determined by the composition of the steel and its final heat treatment.

The above combination of properties generally requires a selective method of hardening which can be most easily provided by induction heating. The hardness actually obtained depends on the carbon content of the steel in conjunction with appropriate quenching conditions. These must, therefore, be controlled with as much care as the heating conditions and provision for this control is a necessary feature of any soundly designed induction hardening equipment.

Three basic methods are used for the induction hardening of gears and the choice will depend on the size, materials and duty requirements of the gear together with other considerations such as the production rate desired.

(1) Through-hardening of the teeth, as the term implies, is not confined to the surfaces only but produces a hardened structure throughout the thickness of each tooth and for a short distance below the root-line (Fig. 8A)

(2) Contour-hardening produces a hardened surface round the periphery of the teeth, extending also round the roots (Fig. 8B)

(3) Flank hardening affects essentially only the sides of the teeth where they contact those of the meshing wheel, although it may be desirable to extend the hardened zone across the roots (Fig. 8C).

(1) *Through-hardening*.—Where tooth design provides ample strength and shock-resistance in the fully hardened material, it is often simplest to adopt through-hardening. It is commonly used for tractor main driving gears and is also the most practical method for many smaller gears produced in considerable quantities since it is characterized by a short process time and relatively simple equipment. The through-hardening method normally provides for hardening all the teeth simultaneously and for this reason the amount of metal heated, and therefore the power rating of the high frequency generator required, may be considerable in the case of large gears. As much as 500 kW of H.F. power is applied in some high-production installations which treat tractor drive gears of some 25 in. pitch dia by 5 in. face width at the rate of about 30 per hr. H.F. power requirements may be somewhat reduced by preheating the components to about 300°C, either in conventional furnaces or by low frequency induction heaters which require no special generator equipment.

(2) *Contour-hardening*.—In order to confine the heat pattern to the contour of the gear teeth it is necessary to apply power at a rate appreciably greater than the rate of heat conduction into the material. This means that for any given size of gear, a higher rate of heat input and, therefore, a larger H.F. generator, must be used than in the case of the through-hardening method. Very short heating times of the order of a few seconds only must be used to prevent the heat penetrating through the thickness of the gear teeth.

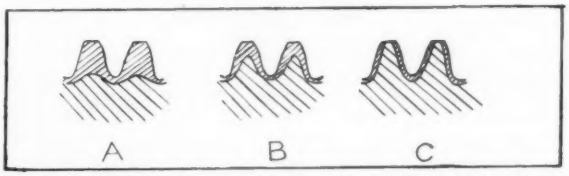


Fig. 8.—Illustrating the three basic methods used for induction hardening of gears

The above requirements mean that in practice contour-hardening is limited to those applications where a high production rate, of the order of 100 gears per hour upwards, is required.

Perfect contour-hardening is usually limited to gears of less than approximately 7 pitch. On finer pitches the teeth are through-hardened no matter what power, density or frequency is used. With coarser gears and using a power density of 8 – 10 kW/sq in. of pitch dia a softer core can be left at the base of each tooth.

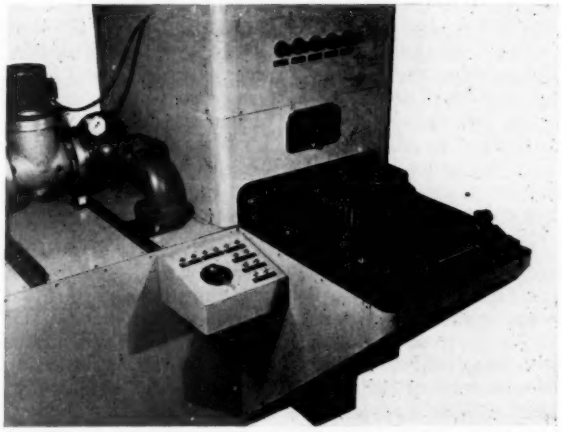
(3) *Flank hardening*.—This method is used mainly as a means of overcoming the limitations on the strict contour-hardening process described above. Since this method heats only a very small area of metal at one time it does not require high power generator equipment. In principle, a special inductor is traversed across the face of the gear, hardening the tooth flanks on either side of it as it passes between them. The gear is then rotated by one pitch and the process repeated, the whole circumference thus being treated in the course of a number of passes. The results are similar to those produced by coutour-hardening, though the production rate is usually lower.

The tooth roots as well as the flanks are usually hardened by this method in order that there shall be no interruption in the hardened surface in regions where stress concentrations may occur.

Fig. 9 shows a gear hardening station with automatic control of heat quench transfer and discharge.

Steels for induction hardening

A wide range of steels can be satisfactorily induction hardened. It is important, however, to have at least 0·35% carbon and preferably 0·40 to 0·45% in order to ensure sufficient hardness. With this proviso, hardnesses up to 60 Rockwell-C or more can be obtained.



International Harvester Co. Ltd.

Fig. 9.—Gear hardening station with automatic control of heat quench transfer and discharge

Where the choice exists it is better to use a water-hardening steel than an oil-hardening type since more

favourable conditions, especially for spray quenching, are obtained.

Most grades of the steels just mentioned will harden satisfactorily at exceptionally fast heating rates. There are, however, some grades, especially air-hardening types, which do not respond quite so rapidly and a slightly longer heating time may be required. When rapid heating rates are used in induction hardening it is often necessary to employ a higher temperature than commonly used in furnace heating. In the case of alloy steels temperatures 10° to 100° C higher than furnace temperatures may be necessary.

Hardness value

When employing induction hardening it is possible to use plain carbon steels hardened and tempered to a high toughness value, which, depending upon the section, is often equal to that for alloy carbon steels or high alloy carburizing steels. This toughness value is certainly high enough for most applications. The hardness value of such plain-carbon steels is relatively low. However, induction heating of this material, because heating can be limited to the surface regions, permits a hard case with a core relatively unaffected by heat and remaining at the toughness previously attained. Apart from any other considerations, there is a saving of alloying elements and hence in cost. The above does not intend to imply that all tough-core case-hardened parts would ordinarily need alloy steels; but they may do so. Heat-resistant stainless air-hardening steels and cast irons are slower to respond to induction hardening, but it is possible to obtain a hardness approaching the optimum in most cases.

Hardness and hardenability

These two expressions are often confused. Hardenability is the ability of a steel to harden deeply from the surface to the same range of values as the surface regions. Hardening is caused by cooling steel so fast that structural changes, which would ordinarily occur, are suppressed. Fast cooling depends, in turn, on rapid abstraction of heat and it is clearly not possible to extract heat as fast from the interior of a body as from the surface regions when the cooling is applied at the surface. There comes a level below the surface when the cooling rate is not fast enough to cause hardening (i.e. slower than the critical cooling rate) and for plain carbon steels this is of the order of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. Alloy steels, however, require a much slower cooling rate to achieve full hardening.

While the cooling rates of a given section or part do not alter very much whether the steel is alloyed or not, the depth to which hardening occurs does vary. Most often induction hardening occurs within the hardenability depth of carbon steels and hardenability is not of much significance. If, however, heating happens to be too deep because of limited power or awkwardness of shape, then a plain carbon steel will give only a relatively shallow case because of its low hardenability. Under the same conditions an alloy steel will give too deep a case and this may result in a part distorting severely or even cracking.

With some alloy steels there is a risk of cracking when using a cold water spray quench. This can be avoided either by the use of warm quench water, by using a mixture of soluble oil and water, a mixture of air and water or by submerging the part in an oil bath after heating.

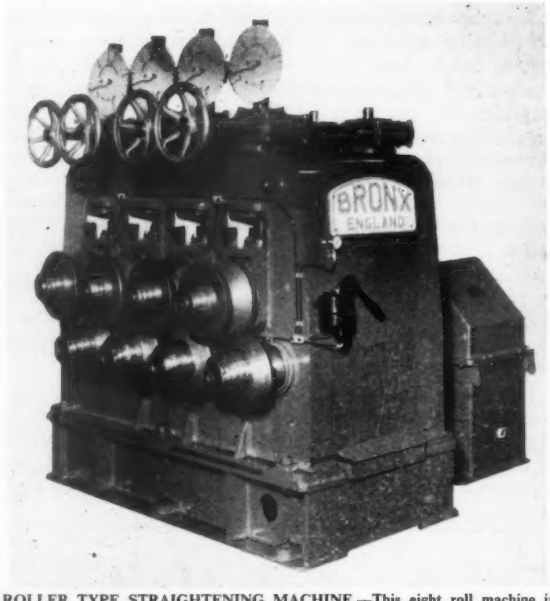
Structure of steels for induction hardening

The structure of the steel to be surface hardened is of some importance, especially in the instance of very thin cases requiring very short heating times. As-cast or spheroidal structures should be avoided whenever possible; a fine-grained normalized condition being the structure to aim for. Very thin cases may require an even finer sorbitic structure.

When required, the normalizing treatment (i.e. heating to about 50° C above the critical temperature and allowing to cool to room temperature) is carried out on the forged or rolled stock prior to all machining operations. When parts have been properly surface hardened there is a gradual change from the hardened case to the unhardened core, and there should be no tendency for the case to flake off.

The induction hardened layer is under compressive stress, which helps to promote resistance to fatigue. In connexion with fatigue properties it should, however, be noted that the transition zone between case and core is under tensional stress and has less resistance to fatigue. No trouble would normally arise from this fact as this zone is well down in the body of the steel. Care should, however, be taken in such parts as crankshafts that the transition zone does not outcrop at a fillet where a stress concentration occurs. The hardened band should stop short of the fillet.

In conclusion, the author would like to express his indebtedness to Birlec-Efco Limited for providing the photographs used in this article and for technical information on their induction hardening equipment.



ROLLER TYPE STRAIGHTENING MACHINE.—This eight roll machine is capable of straightening mild steel angles from 1½ in. up to 3 × 3 × ½ in., channels up to 4 × 2 in., and squares ½ in. up to 1½ in. The top rolls are individually adjustable both vertically and horizontally, and indicators are provided to show their setting. The vertical adjustment is by means of handwheels at the front of the machine, whilst the horizontal adjustment is made at the rear of the machine. A totally enclosed gear unit providing two operating speeds of 100 and 180 fpm is driven by a 35 hp motor complete with reversing control gear. The makers are The Bronx Engineering Company Limited, Lye, Worcs.

New Shears are Accurate and Accessible

A new range of ¼ in. capacity Keetona shears is being made in fabricated steel construction, and with instantaneous clutch engagement, toggle action mechanical hold down (or, alternatively, hydraulically operated hold down), easily accessible blades for changing and one-point lubrication. The modern box-type construction of the new design minimizes deflexion, ensures rigidity, smooth operation and a high degree of accurate shearing to the maximum capacity of the machine.

The action of the cutting beam is inclined at 2° to the vertical. Using square four-edge blades, it presents the corner of the upper blade to the material, giving the same effect as with two-edge bevelled blades. The lower blade is fastened square to the table and is flush with the top. The cutting blades can be straight sided. There is no risk of the sheared material trapping between the lower blade and the back gauge, as the latter moves away from the lower blade whilst cutting. A hand-operated micrometer back gauge is fitted as standard.

The makers are Keeton, Sons & Co. Limited, Sheffield.

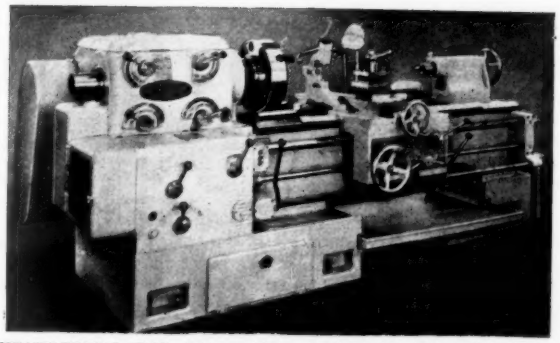
Hand-operated Portable Injection Moulding Machine

A portable injection moulding machine which weighs only 14 lb and is only 18 in. long, and which is used after the manner of a breast drill by turning a handle, offers great scope in jointing, sealing, riveting and plugging in an untold variety of applications. For example, air-tight grommets can be moulded around components passing through bulkheads, non-screwed watertight joints can be made in pipes, and bushes can be moulded into housings around shafts after assembly. Dies for the machine are easily made by casting in low melting point alloys, in special plasters, in rubber, or in cold setting "liquid steel". Fourteen revolutions of the crank handle inject 1¼ cu in. of plastics at a pressure of up to 2500 psi without much effort. A quick locking fixture enables the mould to be secured quickly to the nozzle, and there are a couple of connexions for water cooling for when the machine is in prolonged use. The machine is made by Asmidar Plastic Moulding Machines Limited, 10 Tachbrook Street, London SW1.

Spray Gun Improvement

When air compressed to a pressure of 60 to 80 psi travels through the tortuous paths formed in the body of a spray gun, there is inevitably a pressure drop caused by skin friction to the passage of this air. The Bullows-Binks Model 19 spray gun, which is widely used both in this country and overseas, has been the subject of considerable development work on this problem. By making minute drillings to all parts of the air passages, it has been possible to study the behaviour of the airstream in terms of velocity, direction and pressure within the gun body.

The lessons learned have been applied to all guns now produced, and modifications to the air passages have produced a substantial improvement in performance of this gun with all its high speed setups. These modifications can be made to existing gun bodies at the maker's works (Alfred Bullows & Sons Limited, Long Street, Walsall, Staffs.) at a cost of 10s. 6d. per gun.



HEAVY DUTY LATHE.—This new 18 in. swing heavy duty lathe made by Henry Broadbent Limited, Sowerby Bridge, Yorkshire, is of exceptionally robust construction to withstand the heaviest cuts without deflexion. Extensive use is made of high tensile steels and ball bearings in the mechanism and no tumbler lever is employed in the gear box. Feeds are interlocked with the screwcutting motion and the leadscrew is constantly under tension

Electric Motor for Vibrating Drives

A new electric motor specially designed for vibrating drives, the first of its type to be made in the United Kingdom, is being produced jointly by The English Electric Company Limited and the Grantham Electrical Engineering Company Limited.

The completely self-contained unit provides an inexpensive and reliable drive by eliminating all the mechanical parts associated with an eccentric shaft arrangement. Vibration is generated by out-of-balance weights at either end of the motor which can easily be adjusted by single bolts to give the required output.

It is of robust construction, having heavy duty bearings with special features to deal with out-of-balance loads. Tests have shown that a bearing life of many thousand hours can be expected. The bearings are lubricated for life.

The motor is totally enclosed, dust-proof and weatherproof. The frame is of nodular cast iron, with integral feet, and the shaft is of high tensile steel to withstand the high centrifugal forces to which it is subjected.

Because of its vibrating motion, the motor must be mounted on a resilient base. Operating at 1,500 rpm synchronous speed, it has a power output of up to 7,500 lb centrifugal force, or 10,000 lb at 3,000 rpm, which is ample for all applications at present envisaged. The motor is operated from a 3-phase 50-cycle supply at 110–650 volts. Greater outputs and other supply frequencies can be provided for.

It is built to B.S. 2613, having Class "E" insulation on the windings, which permits a temperature rise of 65°C in a surrounding temperature of 40°C.

It can be used wherever a vibrating motion is required. Typical examples are drives for conveyor, screening, hopper and continuous drying systems (especially those for dealing with loose material in bulk quantities), tamping equipment (e.g. for pre-cast concrete) and machines for breaking or grinding down material into smaller parts, from materials as heavy as granite to those as light as plant leaves.

The new motor is being marketed by both English Electric, Bradford, and the Grantham Electrical Engineering Company, 6 Wharf Road, Grantham, Lincs.

technique

—devoted to the discussion of practical problems
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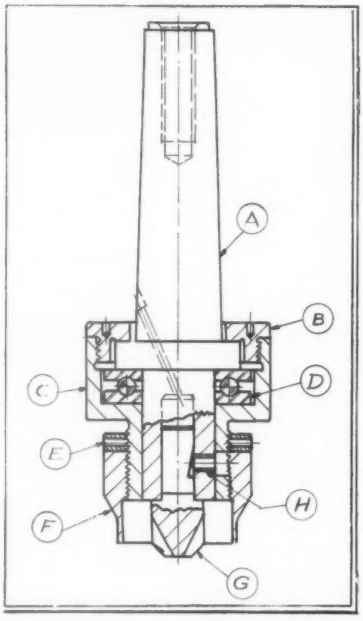
Countersinking Without Surface Damage

Occasionally components are encountered which require the removal of a jig before such subsidiary operations as countersinking and counterboring are possible—a typical instance where this occurs is seen when large windows require a series of holes drilled round the framework, and the work is performed with the aid of a fabricated jig made up from angle and T-iron placed over the component. Due perhaps to the comparatively small quantity of articles that require machining, a cheap jig is essential or one which is easy and light to handle; thus all elaborations in the nature of slip bushes are avoided and the secondary operations are carried out by a tool without the usual pilotage.

The latter is not so important as initially deemed necessary because the drilled hole makes an admirable site from which to pilot the type of tools needed for the operations mentioned above, and it becomes a simple task to insert such a cutter in the spindle nose of a radial drilling machine and complete the work without much attention to final accuracy.

One disadvantage with work of this character is the oftimes rather great difficulty of providing a satisfactory stop for the cutter if the machine does not possess one, and it means that a direct contact with the workpiece is required in order to achieve something like the desired accuracy.

A special cutter designed under these circumstances is illustrated here and consists of a tapered shank A in the orthodox manner but flanged to provide a stop surface for the cap B. This has the usual tommy holes for tightening purposes, and for convenience these are arranged in the upper surface of the cap. This cap holds the bored nut C and serves the dual role of making a seating for the thrust race D and at the same time is extended at the lower end for the collar F and locknut E. A fairly fine thread is preferred at this point as this gives closer adjustment.



Complete freedom from trouble and particularly easy adjustment are the main features of this cutter, and though essentially a countersinking tool it nevertheless will allow counterboring to be performed if a pilot is add to the cutter

The cutter is located and clamped in the holder A and as the thrust is considerable, the holder is provided with a groove into which the cutter is inserted, the latter being provided with a tenon for driving; the grub-screw H thus only holds the cutter in the holder and does not take any part in driving.

With tools of this nature the cutter removal can often present an awkward problem especially as the design shown here has in addition to the surrounding end portion of the cap, two nuts that govern the depth of the countersinking, making it necessary to include access holes. As such a hole is of little use in the collar because adjustment can seldom bring it directly over the grub screw, only one drilling is included through the nut and this is sufficient as cutter removal demands resetting of the collar, thus the temporary removal of the latter is not a serious matter, and it is soon replaced after the cutter has been tightened. The centralizing of the nut hole with the grub screw merely requires a slight rotation of the nut until both match each other and a socket spanner loosens the nut and so allows the cutter to drop away.

Some care is needed with a tool of this design as there is a risk that it can score the surface of the work, so the initial travel is carefully watched until the nut almost touches the work, then the nut is gently gripped and thus prevented from rotating and the remaining few thousandths taken until the lower surface contacts the top of the component. This method overcomes any tendency for the cutter stop collar to produce a few anular markings—they are not really grooves because the surface is not scored to any perceptible depth but just sufficently to cause an unsightly mark.

For cutter removal a piece of silver steel is pushed through the drilling shown in the sketch and the cutter pushed out.

An advantage of the design is the complete enclosure of the thrust race. The surfaces of the flange, cap and nut are adjusted to give a running fit and this also prevents even the smallest pieces of swarf from entering. If the race is packed with thick grease on assembly it will last for many weeks of average usage.

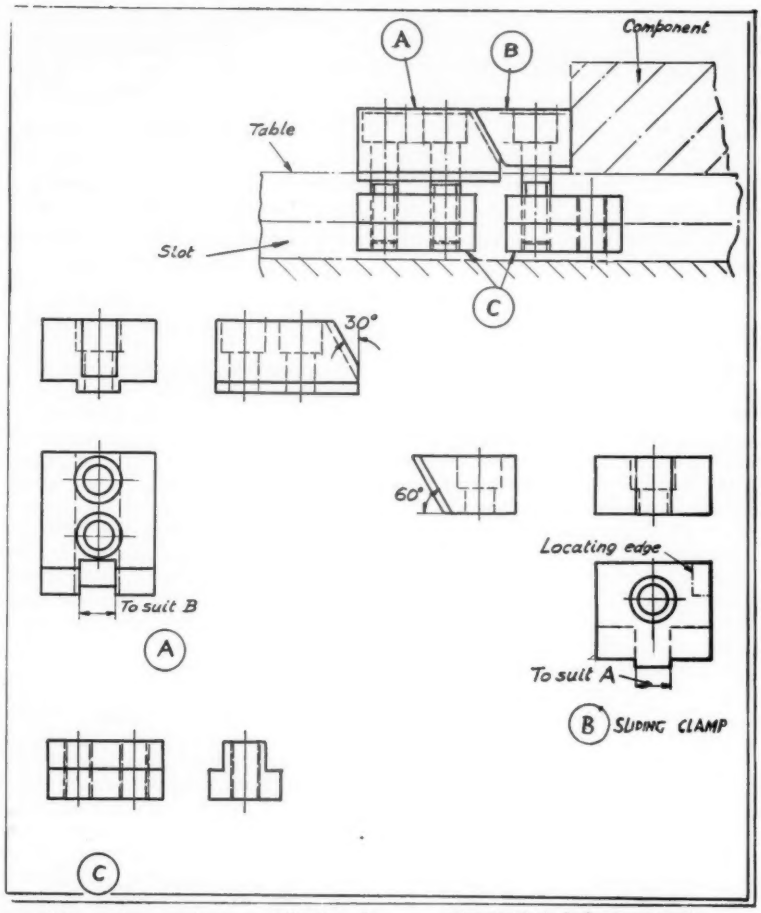
A holder of this description requires carefully making and ground faces on the flange, cap and nut. Hardening is also essential.

Another advantage is the cheap cutter employed, and the grinding of a plain shank alone is a saving.

Finally, setting to depth is easy, either by trial and error or by a dial indicator over the end of the cutter. If the cutters are made to a gauge, then standing the holder on parallel strips under the cap and setting the dial indicator to the protruding face of the cutter will give a reading which is quickly compared with the surface of the collar. Errors are soon corrected by adjusting the latter until the correct degree of protrusion of the tool is achieved.

Clamping Blocks for Large Components

There are many occasions, particularly in planing and milling, when the work is too much for the average



Clamping blocks for large components

machine vice and a method of clamping which will allow the tools to pass completely over the surface of the work without having to move clamps is an advantage, while a heavy sideways pressure equal to that obtained from a vice is still needed.

The old practice of using hold-downs in a vice is well known and for workpieces requiring finishing cuts they give satisfactory service, but their application on a planing machine engaged in taking cuts ranging to $\frac{1}{4}$ in. deep will result in the tool pulling the detail from the clamping hold.

Undoubtedly a sliding jaw is the most efficient method of securing components of this nature and the adoption of such clamping pieces as depicted in this drawing means that the holding member is sufficiently large enough to accommodate socket screws at least $\frac{1}{2}$ in. Whit. which permit the operator to exert a firm pressure capable of resisting the type of cuts experienced in that class of work.

The stop block A is machined with a steep angular facing in addition to the angular keyway, and this is maintained in the correct position by a tenon milled on the base. Two socket-head screws hold this part to the machine table at a suitable distance determined by the width of the sliding block B. This latter part, as the drawing shows, is the clamping member and differs from the previously described block in that it has a matching key and angular surface but does not have the tenon because it must necessarily clear the table surface. For this part a single screw is enough if several clamps are to be used.

Both the stop and sliding blocks use the usual T-nut which operates in the slots of the machine table, and as two screws are needed for the fixed part a similar screw will suit the sliding clamp assembly as there is no point in using two different styles of nuts.

The angular key and keyway is useful for ensuring a positive location for a side stop when this is necessary —a portion of the sliding member is cut away and this can serve as a location against which a detail is pushed while at the same time the sliding action clamps the workpieces. A small portion cut away after the style of that indicated in the plan view of the clamping item B is sufficient. Again, there are occasions when a stop is needed on the machine table and a clamping action on the part of B is unnecessary; the two pieces are then locked together by tightening the sliding part directly to the machine table. The key then keeps the front face at right angles with the tenon and a perfect stop is thus secured. All parts are case hardened.

Flame Cleaning Steel Structures

Two recent flame cleaning jobs have been a blast furnace and a gasholder full of gas.

Four of Europe's largest blast furnaces, at the Appleby-Frodingham Steelworks, Scunthorpe, are periodically flame-cleaned but recently however there was a departure from the usual method in that oxygen and dissolved acetylene were used instead of oxy-propane, and different equipment was employed. Using two sets of British Oxygen "Saffire" equipment, and with six operators working 24 hours a day, the job was completed in a week. Oxygen was taken from the pipeline on the furnace and dissolved acetylene from manifold cylinders. This method showed a small saving in time but its most important advantage was that all scale was removed down to the base metal. The outer shell of the furnace is water-cooled and consequently liable to heavy corrosion. Protective painting is not desirable, however, as the layer of paint would tend to insulate the heat and reduce the efficiency of the cooling system.

The gasholder is a three-lift 430,000 ft capacity column guided type about 80 ft dia at Leamington Spa Gas Works. The process was carried out prior to the holder being painted.

The whole of the side sheeting of the three-lifts was cleaned using Saffire equipment with 4 in. flat nozzles supplied by British Oxygen Gases Limited, in conjunction with needle gun descaling equipment to remove the millscale. A strip cleaning technique of passing the flame over the metal surface was used to avoid overheating and distortion.

Dip Plating Processes

Despite certain limitations chemical or immersion plating is finding increasing application in industry—the main advantage being the uniformity of the resulting electroless coating. Of the three methods discussed, displacement, contact and chemical plating, the last offers the greatest possibilities but the continuous regulation and replenishment of the complex solution employed does necessitate elaborate plant

By D. J. FISHLOCK

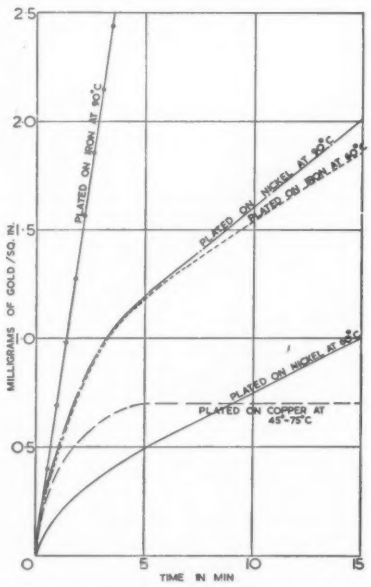
THERE is nothing new about chemical or immersion plating, i.e. depositing a coating of a metal or alloy by a simple dip instead of by the much more elaborate electroplating and electroforming techniques and certainly some methods of depositing tin and silver date back to the 19th century.

Three types of immersion plating can be distinguished: the oldest, displacement plating; the second, a closely related phenomenon, is contact plating; and the third and most recent one to achieve commercial status has been variously termed chemical, electroless and reduction plating. This last type is by far the most promising, by virtue of the physical, chemical and mechanical attributes of the coatings, but the others also have distinct commercial applications today.

Displacement plating

Displacement and contact plating processes are both electro-chemical reactions, the deposition potential necessary being generated within the solution; in the former case it is in tiny electrolytic cells on the surface of the immersed metal, and in the latter in a cell created by suspending the article by or in contact with another, soluble, metal wire, for example. In each case a solution of the metal to be deposited is necessary. In displacement plating the deposited metal is obtained from the solution, and is replaced by an equivalent number of metal atoms from the immersed article. This means that once the immersed surface has been coated with metal, deposition ceases. In practice, porosity of the deposit usually ensures some continuing deposition but if a coherent and adherent deposit is required the limiting thickness is around 0·001 in.

Displacement plating none-the-less finds several industrial applications, an important one being the electroplating of aluminium and magnesium where an extremely thin zinc film is first deposited. A strongly alkaline solution of zinc is used to simultaneously strip the oxide and apply the zinc to aluminium; for magnesium one containing phosphate and fluoride is in use; in each case the zinc film can then be built up by electroplating with the requisite metal or metals. There is some use made of displacement plating in metal colouring, e.g. 'whitening' alloys of assorted colours with tin or silver, or producing a grey finish with an arsenic solution. Copper and its alloys may be coated on steel as a very temporary tarnish inhibitor or to aid lubrication. Nickel is used in this way both as a cheap 'whitening' method and also as an undercoat on ferrous metals to assist the adhesion of vitreous enamel. There is also a nickel dip which produces a jet-black finish on zinc alloys.



Baker Platinum Division, Engelhard Industries Limited

Fig. 1.—Plating rates of the Atomex immersion gold solution on various base metals: ½ oz per gal concentration, pH: 7 to 8

Currently an immersion gold plating solution has found industrial acceptance in a diversity of decorative and functional roles. This is a nearly neutral proprietary solution which operates at between 60° C and boiling point and deposits a relatively dense 24 carat gold coating on many metals and alloys including copper, iron, nickel, zinc, and lead and tin alloys. The speed of deposition varies with the metal and increases with temperature, Fig. 1. Other than temperature control the only process control necessary is for solution pH, which is maintained with indicator papers and additions of ammonia. Gold is removed from the solution until the latter is exhausted, when it is discarded. This simple process, which requires only an inert heated container for the solution and suitable arrangements for thoroughly cleansing the work to be plated, is now in use in the jewellery, electronics (printed circuits, contacts, etc.) and automobile industries, among others.

Contact plating

The most widely used illustration of contact plating today is probably the contact tinning of aluminium alloy i.c. engine pistons to assist 'running in'. For this an alkaline sodium or potassium stannate solution is used, with an aluminium contact metal to provide the internal e.m.f. The process can be regarded as electroplating at very low current densities, but with the salient advantage of avoiding the involved pretreatment sequence which aluminium otherwise demands. The following processing sequence is in use:

1. Solvent clean.
2. Clean for 1 to 2 min in mild alkali: cold rinse.
3. Dip in 20% nitric acid at room temperature for 30 sec.: cold rinse.
4. Plate for 3 to 5 min at 57° ±

2° C in the following solution:
Potassium stannate
68 gm per litre.
Potassium hydroxide
4 gm per litre.

5. Cold followed by warm rinses: dry.

This can be carried out on automatic machines for large-scale plating, in which case provision should be made for automatic temperature control and the continuous replenishment of the solution with additions of potassium stannate and acetic acid.

Liquor finishes for steel wire, used both to aid drawing and to provide a cheap, semi-decorative protection for certain purposes, are also applied by immersion plating. Various colours are available, from a satiny white provided by pure tin, through the different shades of brass and bronze to pure copper.

One protective application is in the manufacture of steel wire for motor tyre beads, where the finish both strengthens the bond to the rubber and protects the steel from corrosion by the sulphur present. The term 'liquor finish' actually originated because the dip-plated wire was immersed in a vat of fermented liquor made from rye meal and yeast; this served as a lubricant in the subsequent drawing operation. Today, however, with improved dip coatings, the liquor dip is often dispensed with.

Chemical plating

The third type of immersion plating, for which the term chemical plating is usually reserved, is probably the oldest in origin since its antecedents can be traced back to 1844. Chemical plating results from chemical reduction reactions which take place within the plating solution when the work is immersed. The solution is metastable and the introduced metal catalyses the chemical reduction, either *per se* or via traces of immersion deposited metal on its surface. The reactions are continuously catalysed by the depositing coating and the latter can be built up at a constant and rapid rate from a correctly maintained solution, to depths dictated only by the limitations in its mechanical properties. Thus, we have a process which offers significant advantages over the previous two.

The commercial development of chemical plating dates back only to 1948, when an American firm began to investigate the possibilities of the

General American Transportation Corp.

Fig. 2.—Railway tank transporter car lined with 5 mil of Kanigen chemical nickel plate to resist the corrosive action of very hot caustic soda

nickel deposit as an alternative to electroplated nickel as a liner of tank cars transporting strong alkali, Fig. 2. The deposit, however, is actually an alloy of nickel containing up to 9% phosphorus, derived from the decomposition of the reducing agent in the solution. Also known at that time were cobalt/phosphorus and Ni/Co/P alloys. The Ni/P alloy has since become by far the most extensively developed and used, but lately patents have been taken out for solutions which will deposit alloys of gold, iron, copper and chromium, with phosphorus based on similar principles; the future of this coating technique is therefore most assuredly promising.

It is with the nickel alloy, however, that we are most concerned at present. Much development has been expended on making this a commercially practical process and it is now available both as a contract process and under license in this country. In comparison with an electrodeposit it has two particular distinctions, one advantageous, one otherwise.

The great advantage—and this applies to all similarly plated alloys—is the uniformity of thickness of the coating. The throwing power factor encountered in electroplating, due to which areas of a component near to or facing the anode will receive more plate than those remote or shielded from it, plays no part in chemical plating. Wherever the solution can circulate freely in contact with the component at optimum temperature and composition the plate will deposit at a uniform rate. This means that a fully protective coating can be applied to virtually any shape, internally or externally, without complicated jigs.

The prime drawback, however, is the solution itself. Even by comparison with modern plating solutions it is extremely complex, comprising eight or more constituents, and it must be operated nearly boiling for fast plating rates. In addition, the composition and purity

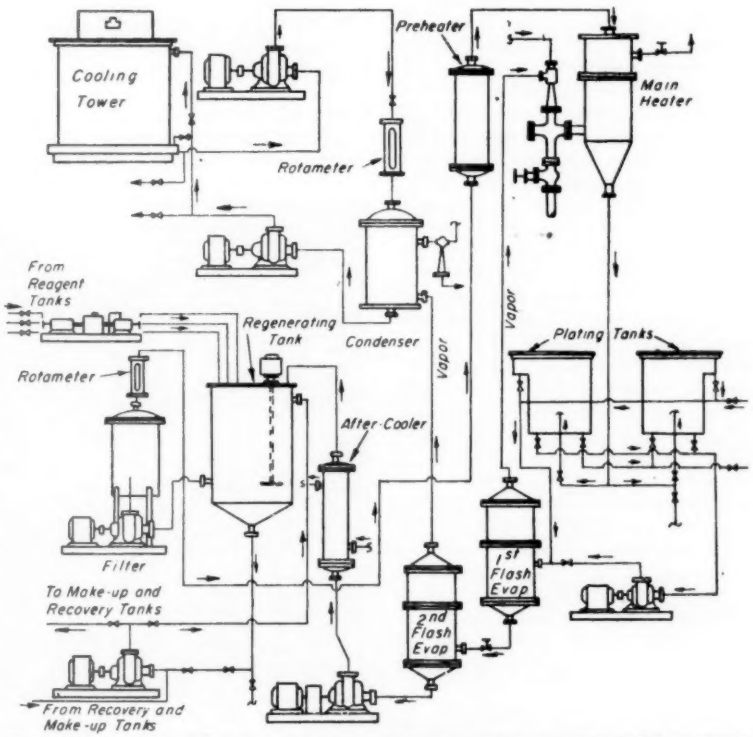


Fig. 3.—Diagram of the complex physical and chemical regeneration system necessary for the Kanigen chemica plating process

of the solution must be closely maintained both to ensure that deposits which are uniform in structure are produced and to prevent the solution from breaking down—a very costly contingency. Fortunately elaborate analysis is unnecessary, and the solution can be controlled from its pH value, with all constituents added on a proportionate basis. The regeneration system is highly involved, since the make-up chemicals are added continuously and they must only be added to the relatively cool liquour. The elaborate plant required for treatment, make-up and filtration is shown in Fig. 3.

It is the cost of such an installation which has chiefly restricted the more widespread use of chemical nickel. At present there is one Kanigen* plant in operation in this country, engaged on plating for the trade. At least eight American and several French Kanigen installations are in current use, though, it is understood that certain British and American firms are developing their own, simpler systems. One such system, not yet commercially available, is based on the use of a less complicated and cheaper solution which is relatively ephemeral.

Plating practice

The plating technique closely follows that for electroplating, in that very thorough cleaning and surface preparation are essential for sound deposits. A general purpose cycle comprises: vapour clean, alkali clean, pickle, alkali clean, pickle, chemical plate. Most metals, with the exception of a few which 'poison' the solution, can be plated directly; the exceptions are tin, lead, cadmium, antimony, zinc, and bismuth, and their alloys. Many alloys, especially high alloy steels and light metals, require a special etch or vapour-honing treatment to secure strong adhesion. Non-metals can also be plated, their surface being first lightly abraided by tumbling or vapour-honing after which it is activated by brief successive dips in:

(i) an acidified 0·044 to 0·1% palladium solution.
(ii) very weak sodium hypophosphite solution.

Another method of activation is to incorporate nickel powder in the plastic or ceramic materials before moulding.

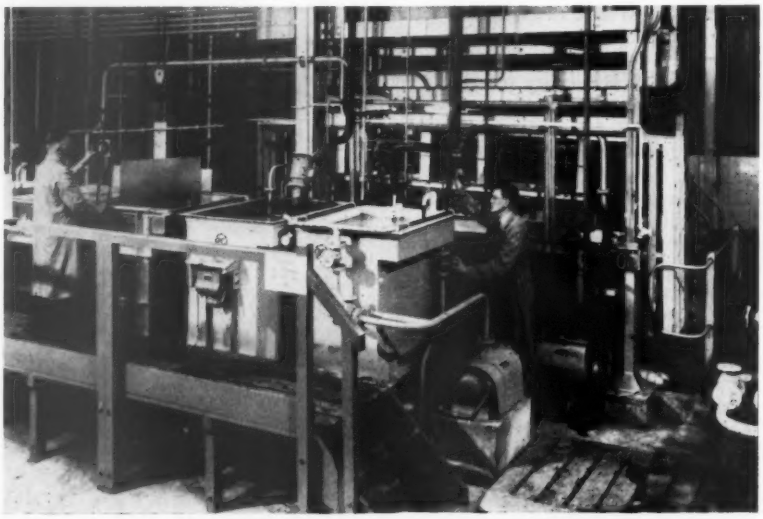
The chief method of plating is by direct immersion of the parts into the plating vat, Figs. 4 and 5; metals such as copper and silver, which lie below nickel in the electropotential scale require to be touched with a more acidic metal, or to be briefly made cathodic with a weak current to initiate deposition. The near-boiling solution circulates rapidly due to convection, but allowance must be made for air-pockets and for accumulations of hydrogen gas, liberated during the reactions. For some shapes it is desirable to rotate the work whilst plating. When coating the interior of large vessels it is sometimes more practical to use the vessel as a plating tank, while alternative systems include pumping the solution through large items and injecting the solution into a continuously rotating hollow vessel. Solution agitation is recommended with the Lustralloy process, since it brightens the deposit and tends to displace any traces of soils or nickel particles.

Racking presents few problems, since there is little shielding from attached wires or contacts, and for thicknesses up to 0·002 in. no mark is left; above this the plate may be somewhat thinner where shielded. Small parts can be barrelled, using a low-speed Melamine barrel for preference, with no loss in deposit uniformity.

Coating properties

Nickel/phosphorus alloys are quite unique metallurgically. Their structure is that of a super-cooled liquid, i.e. non-crystalline and, unlike electro-deposits, is unrelated to that of the base metal. It is thought to be the first instance of an amorphous metallic solid in any quantity. As deposited it has a hardness around 500 V.P.N. (49 Rockwell 'C') but is metastable. Above 300° C it changes to the equilibrium state with a large energy release and the precipitation of finely divided nickel and nickel phosphide (Ni_3P) crystals; by low temperature heat-treatments, therefore, marked increases in hardness can be obtained, Fig. 6. Higher temperature treatments, however, are used to improve the ductility which tends to be very low—3 to 6% elongation—for the as-plated alloy. For instance, 90 min at 600° C in an inert atmosphere raises the hardness of Kanigen plate to 650 V.P.N. and increases the ductility and wear-resistance; 760° C for five hours, followed by slow cooling to 200° C gives maximum wear and impact resistance, maximum ductility, and an increased salt-spray resistance.

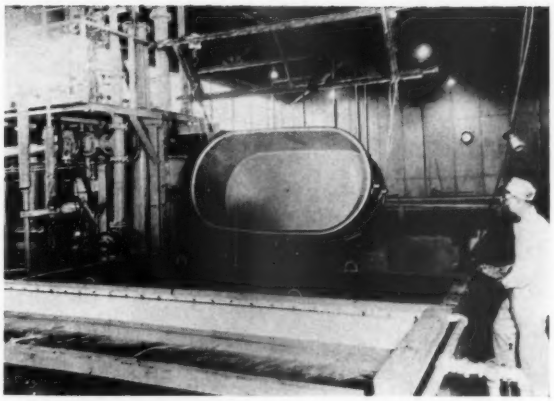
The coating follows the surface of the base metal very closely and thus reproduces its surface finish. Brighteners are often incorporated in the solution which, on a polished substrate, give a fully polished deposit at all thicknesses. This even applies to internal surfaces, such as the insides of taps and narrow orifice nozzles. The alloy is also extremely dense and apparently quite free from porosity even at depths as thin as 0·0002 in.; a comparable free-



Albright & Wilson (Mfg.) Limited

Fig. 4.—A view of the Kanigen plant in which metals are plated with a nickel phosphorus to give a hard and corrosion resistant plate

* One of the most highly developed chemical nickel processes, developed by the General American Transportation Corporation.



General American Transportation Corp.

Fig. 5.—Chemical processing tank about to be immersed in a chemical nickel plating bath

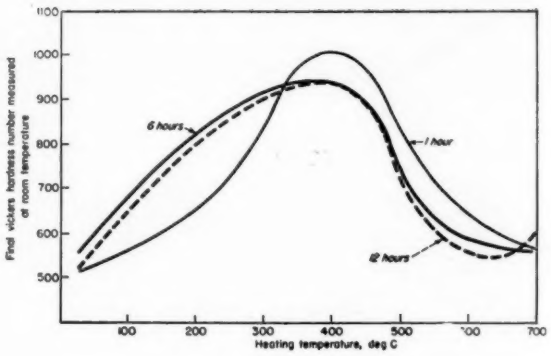


Fig. 6.—Heat treatment curves of nickel-plating by chemical reduction. Data were obtained by heating the part in an inert atmosphere and holding at a specified temperature for 1, 6, or 12 hr. The parts were cooled slowly to 200° C, then removed from the oven. All measurements, taken on the top surface of 0·005 in. plating on cold rolled steel, were made at room temperature

dom from pores in electro-deposited nickel can only be achieved with extremely refined laboratory techniques. The adhesion is also very strong, despite the absence of any tendency for the substrate's structure to be continued into it, and no gap has been detected between substrate and coating; the bond strength lies in the region of 15–30 ton/sq in. The physical and mechanical properties of the Kanigen alloy are given in Table I; this has the nominal composition of 91·3% nickel and 8·7% phosphorus, with traces of carbon oxygen, nitrogen, hydrogen and heavy metals. Other chemical nickel deposits have closely similar properties.

Application of chemical nickel

These are now extremely varied, but can be broadly divided into two categories, viz., corrosion resistance and engineering. The relatively high cost militates against purely decorative application, such as its replacement of electro-plated nickel as an undercoat for chromium, with the possible exception of components of complex shape required to have a high corrosion resistance on recessed or internal faces.

The corrosion resistance of nickel/phosphorus alloy appears to be slightly greater than that of pure nickel, and it has an especially high alkali resistance, which makes for its extensive application in chemical engineering. The tank car shown in Fig. 2 is used to transport 72% caustic soda solution, and is loaded at 130° C. The rate of attack on Kanigen plate is a mere 0·00007 in. per year. Many milder corrosives can be handled with no discernible attack, this including many weak acids. In general, though, the alloy is not recommended for contact with acids, particularly solutions below pH 4·0. The alloy is now used for protecting steel, in particular in chemical plant of all types, from valves, Fig. 7, pipework and pumps up to large reaction and storage vessels. The thickness of plate depends on the corrosion resistance and the surface finish of the substrate, but will generally be from 0·002 to 0·005 in. Industries include chemical manufacture, food processing and atomic energy; in the latter case it is used to protect both heavy plant and remote handling equipment, but the specific details remain classified. On small complex shaped parts such as screws, bolts, gears and coiled springs, notoriously troublesome to coat adequately by electrochemical processes, chemical nickel can supply almost an ideal finish for many applications. The coating is perfectly uniform and doesn't alter the all-important thread or gear-tooth profile, while its hardness and wear resistance prove additionally advantageous here. In the case of springs an undercoat of chemical nickel has been suggested to prevent the steel absorbing hydrogen, during cadmium plating, for instance, and thus preventing its embrittlement. Relatively thin deposits, i.e. less than 0·001 in. are now competing with electroplated finishes for protecting radar equipment destined for the tropics and to protect laundry and dishwashing machines. Also, it has a better heat-resistance than cadmium and finds many applications at temperatures of 230° C and above. It has also been found very useful for preventing iron contamination of solids, liquids and gases of all types.

The engineering applications are

Table I.—COMPARATIVE PROPERTIES OF KANIGEN AND ELECTRO-DEPOSITED NICKEL PLATE

Property	Kanigen Plate	Dull electro-deposited nickel (Watts type solution)
Composition	Approximately 8·5% phosphorus, remainder nickel	99·5% or more nickel
Structure	Amorphous	Micro-crystalline
Melting point	890° C	1450° C
Resistivity	About 60 micro-ohm/cm	About 8·5 micro-ohm/cm
Specific gravity	7·9	7·7
Hardness · as plated after heat treatment	550 ± 50 V.P.N. 1025 ± 50 V.P.N.†	150 to 250 V.P.N.* Not amenable
Adhesion to steel	30,000 to 60,000 psi	50,000 to 60,000 psi
Elongation	3 to 6%	10 to 30%‡
Abrasion resistance as plated	13·7**	14·700
Type of stress	Compressive††	Tensile
Porosity	Nil on 0·0002 in.	Usually marked on 0·0002 in.
Magnetic susceptibility	4·0%	37·5%
Micro-throwing power	Good	Poor without addition agents
Throwing power	± 10% maximum	Wide variations
Plating rate	About 0·001 in./hr	About 0·001 in./hr at 20 amp/sq. ft

* Bright and high chloride solutions much higher, 400 to 500 V.P.N.

† Heat treatment at 400° C for 1 hr produces this value: examination of structure reveals a precipitation of finely divided nickel phosphide. Ductility is, of course, reduced by heat treatment.

‡ Lower, 1 to 15%, with bright and high chloride solutions.

** Measurements made on Tabor Abraser, using C310 wheel and 1 Kg load for 5000 cycles. Hard chromium was 2·04. Heat treatment considerably improved wear resistance of alloy.

†† Although the ductility is low, the compressive stress prevents much of the cracking which afflicts many bright nickel deposits of comparable ductility.

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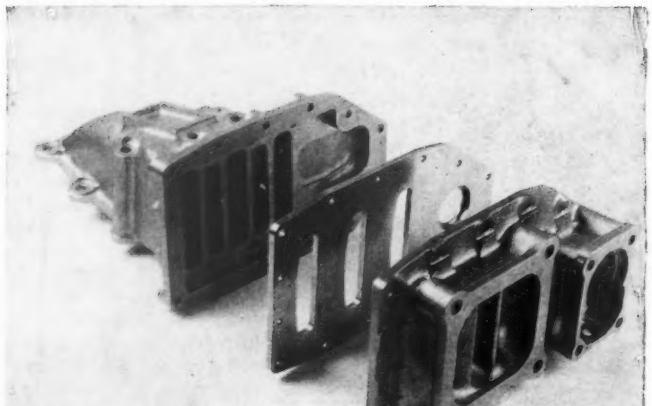
Fig. 7.—A 3 in. two-way plug-type cast iron Audco valve manufactured by the Audley Engineering Company Limited, plated all over with 0·002 in. Kanigen for corrosion protection



Teddington Aircraft Controls Limited

Fig. 8.—Light alloy gate valve used in air-conditioning systems. Air passage through the valve is controlled by a sliding carbon gate sealing against a slotted plate interposed between the body casting. Through air temperature is about 350°C. and pressure 150 psi under normal conditions. Main problems are galvanic corrosion due to potential difference between carbon and metal, and rapid wear of the casting in contact with the gate. Kanigen, by interposing a parting layer between carbon and metal, has eliminated the corrosion problem; whilst the low coefficient of friction of the plating has resulted in the carbon acquiring a mirror finish with no apparent wear after 300 hr of cyclic testing. Plating thickness 0·001 in.

equally varied, and are based, of course, on the strength, hardness and wear-resistance of the alloy. In many respects it is superior to heavy nickel electro-deposits and comparable to hard chromium. An important application is the reclamation of worn, corroded or over-machined components where deposits up to 7 mm can fully restore and often enhance the original properties. Masking for selective deposition, once something of a problem owing to the high solution temperature, is now possible with several plastic stop-off materials, though, if the plate is less than 0·0015 in. thick it will probably be more economical to plate the whole article if permissible. Another advantage of this build-up technique is that the deposition rate and surface finish can be so closely controlled that the final machining to size often proves unnecessary.

As a hard-facing process chemical nickel plating is used for items as diverse as tiny gears, threads, bearings, taps and dies, and for heavy engineering plant such as printing press beds, large shafts and crankshafts, and hydraulic equipment. It is especially useful for hard-facing aluminium since it is generally simpler to produce adherent chemical nickel coatings than electro-deposited ones, Fig. 8. Another large application for aluminium is to improve its solderability, and 0·003 in. deposits are now often used on sheet aluminium for radio chassis. Although not recommended on parts liable to rub together without lubrication, it is now being used on 300 series stainless, 4100 alloy steels and lately on titanium to reduce or prevent galling.

Chemically plating other metals

In the American G.E.C. laboratories they have had some success with a chemical reduction method of depositing copper. An alkaline solution based on copper tartrate with formaldehyde in place of hypophosphite and used warm was evolved which appeared to function similarly to the chemical nickel ones. Deposits up to 0·001 in. were obtained on a steel base which had been flash-coated with chemical nickel to initiate deposition; traces of immersion deposited silver or palladium can also be used to 'seed' the copper deposition. The deposit appears to be substantially similar to electro-deposited copper, and is therefore presumably nearly pure. As with chemical nickel the solution is inherently unstable and would need to be constantly replenished and filtered to obtain sound deposits. In view of the importance of copper undercoats in many plating sequences, however, the process well justifies further exploration.

Table II.—TYPICAL COATING THICKNESSES

Thickness, in.	Typical Applications
0·0001 to 0·0002	Watch and instruments gears and worms to increase wear resistance.
0·0002	Non-porous deposits on smooth steel (minimum).
0·0003	To prepare aluminium for soldering.
0·001 to 0·002	Normal service e.g. reasonable chemical resistance.
0·002 minimum	Corrosion resistance on aluminium
0·003 to 0·005	Resistance to hot, conc. alkali or other strong electrolytes.
0·007	Economic limit for most purposes.

Recently patents have been granted for hypophosphite solutions for depositing iron and ferrous alloys, vanadium and vanadium alloys, gold and chromium. The last metal, for instance can be plated from a solution containing 10 gm/l hypophosphite, 17 gm/l chromium salts and various regulating additions, at 75 to 90° C, pH 8 to 10. This is a relatively dilute bath.

Again, the deposition of cobalt and cobalt/nickel alloys from hypophosphite solutions closely similar to those for nickel was first achieved in 1945, but their properties so closely resemble the nickel/phosphorus alloy that their higher cost has not justified commercial development. In all of the above cases the processes are in a very immature state of development, but the success and rapidly increasing range of application of chemical nickel has given considerable impetus to furthering their evolution.

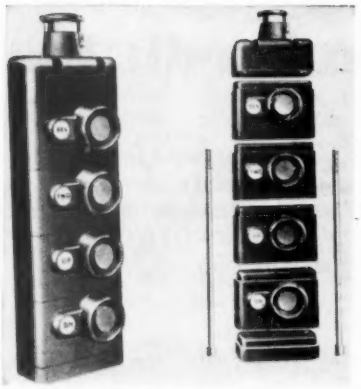
Pendant Control Switch Unit

A new remote control switch assembly for use with cranes and other similar equipment is of unit construction and any size of assembly from one way to eight way, can be made up as required. Each unit contains a push button switch and indicator disc which can be inscribed with any one of eleven different words of instruction or special wording to suit particular applications. The units are held together by a top and bottom segment with internally fixed bolts, the top segment has a cable clamp and the entry is designed for most standard cable thicknesses. This can be adapted for use with heavier conduit by cutting off the narrow neck of the entry. Each unit fits and locks together by means of lips and bosses which prevent relative movement of the units and make the whole assembly weather and dustproof.

Manufactured in neoprene which makes for first-class protection against ozone, oils, greases and solvents, it is completely insulated, virtually indestructible and remarkably light in weight.

The switches are rewirable and are single-pole, double-break changeover type, rated for standard duty on the remote control of magnetic switchgear up to 600 volt a.c. and d.c.

Provision is made for securing straining wires to the top of the assembly, thus ensuring that no weight is carried by the neoprene body or the supply cable.



Remote control switch made of neoprene

The switch unit is made by Nettle Accessories Limited, Harper Road, Wythenshawe, Manchester, 22.

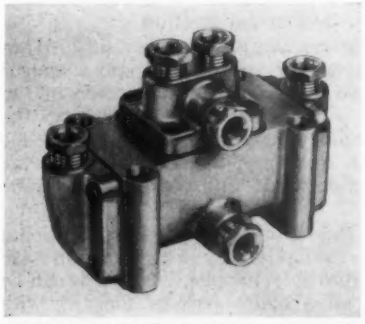
Leak-proof Drum Tap

A drip-proof and reversible drum tap which can be used with many liquids, including paraffin, trichlorethylene, turpentine and others difficult to handle, is now being marketed by Phillips Telescopic Taps Limited, Colliery Road, Birmingham Road, West Bromwich, Staffs. The new tap, which is moulded in Rigidex high density polyethylene, is tough and proof against drip and seepage. There are no internal washers or glands and manipulation is by push button giving immediate on and off action. With a 1 gallon head of paraffin the tap delivers 1 pint of filtered liquid in 10 sec. In transit, the tap travels with the package either under the filter cap or reversed in a $\frac{3}{4}$ in. gas screw fitting.

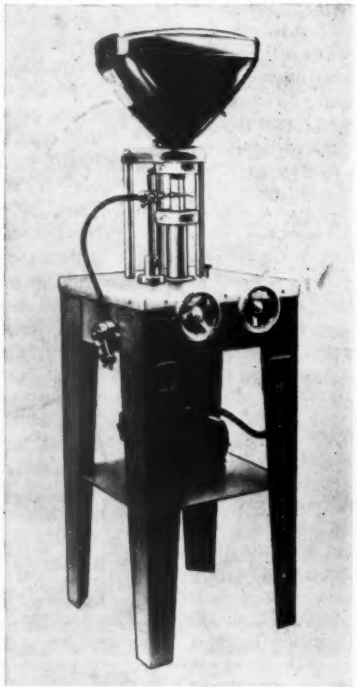
Low Speed Hydraulic Motors

A new range of hydraulic motors features hydraulically balanced bearing loads (except for main bearings, which are tapered roller type) which enables the motors to operate at pressures up to 3000 psi. Another feature is the complete absence of external high pressure seals.

The range goes up to 10,000 lb-ft torque, but the makers, Hydrostatic Transmissions Limited, 33a Balfour Grove, London, N20, offer larger designs for special purposes. All models are available with either stationary shaft and rotating crankcase or rotating shaft and stationary crankcase. Constant or variable delivery pumps can be used to drive the motors and give fixed or infinitely variable output speeds and motors can be reversed without loss of torque.



AUTOMATIC CONTROL VALVE.—This totally enclosed double air operated 4-way automatic valve with full $\frac{1}{4}$ in. ports is of the linear slide valve type, having the operating shuttle and valve slide made from stainless steel, all internal parts of non-ferrous metals and the body from hot brass stampings. To allow maximum sensitivity $1\frac{1}{4}$ in. dia piston cups have been used; thus with 80 psi in the valve chamber the pressure required to operate the pistons is 15 psi and the lowest equal pressure recommended is 10 psi. The makers, Lang Pneumatic Limited, Victory Works, Birmingham Road, Wolverhampton, have designed the valve body so that simple adaptation can provide air operated self-reversing, double solenoid operation, solenoid operated self-reversing, or single solenoid single air operation.



T.V. TUBE RECONDITIONER.—This new piece of equipment for the reconditioning of television tubes has been introduced by the Tapco Tool Company of 35 Slade Lane, Manchester 13. It comprises a compact neck and foot sealing unit embodying a gas mixer valve which gives easy manipulation and accurate control of burner heat

THE PICCOLIFT.—This new fork-lift truck made by G. Hunter (London) Limited, 80 Fenchurch Street, London EC3 possesses all the advantages of the sit-on rider type yet only has a length of 37 in. Capacity is 1120 lb at 24 in. or 1300 lb at 20 in. load centres. Although the truck is three wheeled, there is an independent motor on each front wheel which gives maximum traction for gradient work. Towing capacity is available up to 10 tons, Height of lift is from 60 in. up to 138 in. Drive is by electric traction batteries and cushion tyres are standard

Medium Term Credit Facilities

The now frequent demand for two or three year credit facilities introduces the hazard of inability on the part of the customer to pay for what he takes. That this element of danger is capable of being insured is not widely appreciated. It is particularly important in the engineering capital goods market.

THE layman in need of some engineering product will debate relative value with local stockists and, more often than not, will leave the shop premises with his purchases having paid for them. He has acquired what he set out to purchase and will be satisfied with the results of his excursion. This cash-over-the-counter transaction, frequent as it is, bears, in total, very small relationship to the vastness of the credit transactions which may have been involved during the periods of transition from raw material to finished article which is the end product of engineering craftsmanship. The layman has little time (and perhaps little need) to stop and think of the capital which has necessarily been invested and used in putting what the public wants on the counters which the public will visit.

The credit question which involves nearly everyone in the chain from producer to customer is of extreme complexity but is, nevertheless, based on the most simple considerations of trust and confidence. Whether the sale of raw material is involved or the production of household equipment or any of the numerous in-between stages, the credit question is one which involves the interest-free loan of valuable capital, usually against the unwritten promise to make payment at some tentatively agreed but not necessarily specified later date. Misplaced confidence or trust which ultimately proves unreliable may well be the forerunner of unpleasantnesses of varying degree, the variation reflecting the amount involved and the ability to sustain uninterrupted trading on the remaining free capital. For the most part, the commercial side of engineering is based on a relatively short term credit facility and although substantial credit losses have arisen and will continue to upset unfortunate creditors, the very fact that the credit period is short tends to reduce the seriousness of the impact of bad debts on creditors.

It is not every manufacturer who is in the position of being able to sell his products on the basis of short term credits for the nature of certain productive routines and the inclusive and integral value of the ultimate product regularly involves machinery of a capital nature which has to be designed, manufactured and sold without hope of other than spread payment over a comparatively long period, say, two or three years. In financial parlance such credit facilities are not regarded as 'long'. They are classed as 'medium' and it is only when facilities in terms of credit involve upwards of three years (five to seven years crop up not infrequently) that there is considered to be a swing over from a medium credit facility to a long one. In this article no more than passing consideration will be paid to the five or seven years facilities as these, when they arise, are of sufficient size and importance to require specific and individual consideration. Medium term credits, on the other hand, are now commonplace and, as such, are given much closer attention by the makers of capital equipment, those who finance them and those who share the risk of domestic and overseas credit risks.

When contemplating an order which will, in time, involve manufacture, supply and payment over a medium term period, the organization which has the order under consideration is faced with several problems. It is taken for granted that the initial negotiations relate to a final manufacturing outcome which is within the capacity of the negotiator. He has at least the following influences to consider:

(a) In the event of my accepting this apparently lucrative order will its execution interfere unduly with the production of my bread and butter business?
(b) Is its production within the capacity of my present organization or will it be necessary for me to introduce new plant, new staff or even additional capital to finance it from start to finish?
(c) If I have to do any of these things in a major way, is the expected profit margin worth the disruption and the cost?
(d) Is the standing of the customer such that there is very little *apparent* danger of being let down ?
(e) Even if the buyer comes within the believed 'undoubted' or 'blue chip' categories, would his unforeseen and unexpected financial collapse endanger my own financial position?
(f) In the event of my being reasonably satisfied on these points to what extent will my bank manager expect and ask for security to take care of the extra money likely to be needed during the productive months and to give me the knowledge that he will, if necessary, finance me during the protracted period over which payment will be spread?
(g) To cheapen the cost of any such additional facilities and to render my own position safe should the 'impossible' happen, what steps can be taken to lay off a major part of the risk with insurance protection?

The acceptance of an order which will involve credit facilities spread over two or three years brings into bearing two separated but associated risks, e.g. before delivery and after delivery. It must be agreed that the pre-delivery risk to the manufacturer is likely to be of lesser impact than the post-delivery problems when the whole of the order has been executed, delivery has been effected and the waiting for payment period commences

with a peak load gradually running down and off. Before delivery there is the possibility of some sort of salvage if the buyer fails: after delivery, the right to receive due and proper payment is brought into being but the ability of the purchaser correctly to meet his engagements and to ensure easy progress to the ultimate end depends on so many influencing factors (and factors so frequently outside his own control) that the regular safeguarding of the capital investment through sharing the risk with others is becoming more and more a matter of habit and commonsense in the home and overseas markets than the impulsive seeking of self protection.

The pre-delivery risk

When a contract is entered into for the manufacture and supply of some equipment which takes the form of capital investment, there are numerous contributory elements of expense which will ultimately form part of the complete contract price. Allowance for them, wholly or partially, is made at the time when a tender is put forward and the figures included are obviously based on adequate costing and the benefits of past experience. Normal oncosts which would, in ordinary manufacture, fall within the administrative expenditure heading may not be specifically itemised but, with a special order there must be special costs and among the most obvious of these will be:

Preparing blue prints and, following submission and debate, preparing further drafts until the final state of excellence is achieved.

Acquiring or making special jigs and tools, locating or purchasing ancillary gear or equipment.

Administrative and productive wages and salaries capable of being identified with the job in hand.

In the event of the purchaser, maybe through no fault of his own, being unable to implement his part of the contract—and this may be made apparent at the quarter or half-way stage—the manufacturing engineer is left with the burden of all these exceptional and special costs and may well have his factory premises impeded with half constructed contract material for which, before completion, he is made aware that there is no possibility of delivery.

Thus, in so many cases where specially designed equipment is in course of manufacture, the engineer becomes saddled with some irrecoverable expenditure and, maybe, an asset or liability (whichever way he looks at it) of little more than scrap value. What remedy has he? At that stage he has nothing left which will bring any tangible satisfaction although he can and will make a claim on the trustee or liquidator for what has been done and what has been spent and he will, in time, receive his share of whatever is realized for distribution to the unsecured creditors. The position thus created is far from satisfactory and if the progressive work had been carried to a stage when completion could be exactly envisaged, the consequences may be quite serious and far-reaching. The larger the value of the contract which has been undertaken the greater is the risk of the contractor's stability being strained or damaged. And all this is directly due to circumstances over which he has no direct control. He must take his fate philosophically and hope that the dividends from the estate will be pleasantly substantial: he must, if he himself is not irretrievably damaged, double his activity with his reduced resources in the hope that, given time and repeated opportunity, he can recover the ground and capital of which he has been mulcted.

This is the worst side of the pre-delivery risk. Failures, bankruptcies, prevented completions and absolute prohibitions have been irregular hazards with which all have to cope: they are no novelty and will continue to make their unpleasant impact on the trading funds of the more unfortunate engineer. Some, of course, have never been embroiled and may be lulled into a sense of false security on the premise 'it cannot happen to me'. Others, whether they have been bitten or not, consider that it is well worth while sacrificing a small portion of the anticipated profit on a contract in order to be sure that, if the worst comes to the worst, their own financial balance cannot be upset through the loss of a large portion of their free assets which is placed beyond full recovery. In other words, it is better, slightly to cut the profit by taking advantage of the insurance possibilities and thereby ensure full sleep at nights.

Whether contracts are entered into with customers at home or abroad the same element of hazard exists but, in the export markets the main home risk of loss through insolvency must be added to by the uncertainties of foreign commerce and foreign commercial activity. Outstanding in the overseas market are those additional risks which are generally classed together under the heading of 'political'. These may be in the shape of action by the Government of the buyer's country which blocks delivery. Abroad, a customer may be embroiled in war, riots, civil commotion and other similar occurences of which here we have little experience but which in some parts of the world are by no means unusual. Even if the buyer remains solvent and willing to pay the transfer of the money to the United Kingdom may be blocked or delayed by foreign Government action. Admittedly some of these export hazards do not arise in connexion with the pre-delivery risk and are mainly of influence after completion of any contract. These will be dealt with in more detail later.

In the domestic market where the majority of the engineering industry is engaged in the manufacture of articles for upward delivery, i.e., the provision of components for inclusion in the greater whole being prepared by a larger organization or establishment, there have, in recent months been several shocks which have involved creditors and the loss of considerable amounts of capital.

The protection against loss before delivery is a branch of insurance activity which is widely engaged in for both home and foreign contracts. Where the manufacturer and the buyer are both in this country the only obvious hazard is that of the buyer getting into a position of insolvency and being unable either to honour his financial commitments or go through with his contractual engagements. When such a position arises there is almost bound to be loss for someone and the more important the failure the larger is likely to be the influence upon those who have agreed to make and supply. In the period before delivery—the work in progress period—the danger of contractual loss may be less important than when everything has been executed to order and control over the finished commodity relinquished. Even so, with competition on the increase and the need for self-protection uppermost in the minds of those who control their capital and the capital of others, it is as well and fully advisable to look into the possibilities which the insurance market has on offer.

The post-delivery risk

The value of any asset which is in the form of work done on behalf of a customer lies in its convertibility from a paper asset into cash in the bank. Until then, completed and delivered work comes within the embrace of 'sundry debtors' which, imposing in the monthly trial balances and the annual balance sheet, carry the loan capital and the potential profit but may also hide temporarily the unexpected heartbreaking item which may have to be transferred to 'suspense account' and then to 'bad debts account'. It is when this position in the collection of moneys due and overdue arises that the possible effects have to be calculated. Will an unpaid order or orders involve figures which will make business continuation more difficult or even impossible? Will the bank be less accommodating because the liquid position has been damaged? Will there be anything worthwhile in the way of salvage from the debtor?

It is very certain that when an order is executed for the supply of capital equipment with payment spread over a medium term period, the figures involved must be substantial. Of course, the word 'substantial' has a relative application and what is 'large' to one engineer may be 'dangerous' to another. The difference lies in the background strength and the ability of the contractor to absorb, should the worst some to the worst, a debt for goods supplied. The powerful combine may be able to shrug off a debt of some thousands whereas an equally capable but very much smaller manufacturing organization may find itself bent if the money does not come through as expected.

Practice has shown that the larger the credit-giver the more conscious he is of the implications of non-payment. It is the small to medium organization which tends to rejoice over a substantial order but overlooks (or decries) the possibility of non-payment. Admittedly, in the supply of capital equipment the custom has for long been "cash". It is seldom that the producer is let down during the preparatory stages and his customer has time to make arrangements to produce his bankers' order when he is notified that delivery is imminent. Times, however, change and despite the improved national situation, there is a noticeable gravitation towards the buying of requirements on credit where cash would have been the rule some little while ago. Some manufacturers are already producing for payment over two to three years. They have solved the financial difficulties inherent on credit trading and they are likely to find their approaches much more acceptable than those who endeavour to adhere to "cash only". Those who do this are fighting a losing battle and despite the merits of selling against immediate payment, it is necessary to move with the times and to realize that, competition being what it is, future business is likely to drift to the seller who offers the most convenient accommodation, i.e., credit.

There are other businesses which tend to look down their noses at the possibility of introducing a hire purchase system of payment. Old fashioned ideas are slow to appreciate what the finance market has to offer and will be much more appealed to by credit terms of sale if they can be shown how such a basis can be to their ultimate advantage.

The issue is relatively simple. Provided the payment terms can be arranged to the liking of bankers and there is sufficient security in the shape of accepted bills of exchange, there should be no great difficulty in getting those bills discounted as soon as they are drawn. Bankers are now in competition with the discount market for this sort of business and, although credit terms are negotiated and agreed, discounting of accepted drafts enables the manufacturer to recoup his capital and his profit soon after delivery and to re-employ it to its best possible advantage.

Whether the bills are drawn on a domestic customer or on a foreign importer the possibility of non-payment cannot be overlooked or forgotten. When this occurs (and in the overseas market in particular there can be almost limitless reasons for non-payment of a bill at due date) there is the possibility of an awkward situation. It may well be that the bank or discount house relies solely on the name of the acceptor and if there are any qualms about the financial structure of the selling engineer, repayment may be demanded. In some quarters outright sale of the bills may have been achieved (at a greater cost) and the headache then takes up position in the bank.

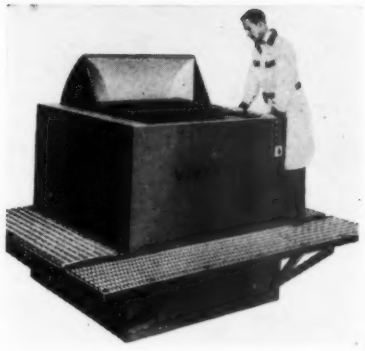
By and large, though, assistance given in provision of finance on medium term credit deliveries, is tied up with some additional security—the risk is covered through insurance. Credit insurance is no novelty but the swing away from cash deals in the provision of substantial engineering products has brought its services more into the limelight. In the home market the main risk is that of insolvency on the part of the buyer and recent events have highlighted the fact that no one is really capable of knowing what is going on behind the customer's façade. High productivity, apparently able financing and accepted probity are the dominating factors of everyday commerce. It is when one breaks down unexpectedly that the greatest misery can occur. This misery can be largely offset if a substantial share of the obvious risk is laid off with the insurance market.

In selling abroad the hazards are substantially greater than in selling in the U.K. Distance is not the deciding risk but there are the extraneous, beyond-the-influence-of-buyer-and-seller factors which can deprive the British exporter of his rights and his money. Some of these have been mentioned earlier but, the specific risks apart, the remainder are summed up as "any other cause of loss occurring outside the United Kingdom and not within the control of the exporter or the buyer, and not normally insurable with commercial insurers."

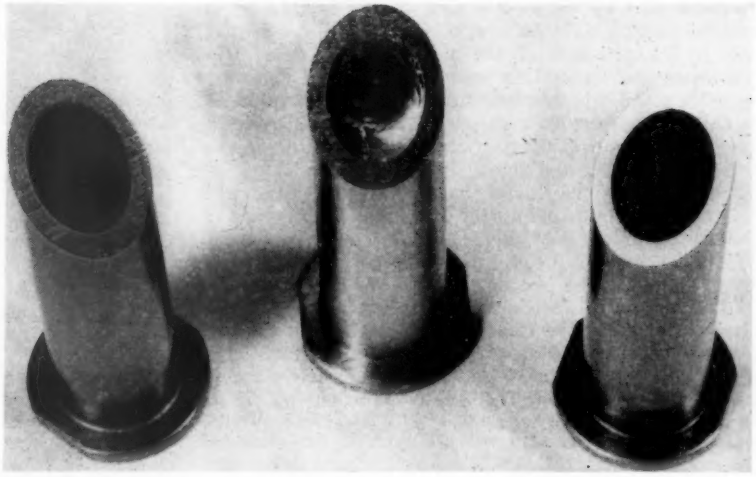
Whilst new capital is relatively easy to come by nowadays the replacement of what is lost through trading risks such as can now be covered is not considered in the markets of finance as being their proper province. That it is the duty of the insurance markets to do so—against a compensating premium—is becoming more and more accepted. Its possibilities are well worth investigating and, in sequence, advice should be sought from bankers, insurance advisers or brokers and the underwriters.

Protective Film for Drawings, etc.

A material called Halco-Sheen which will give drawings and workshop prints a durable glossy finish has been introduced by J. Halden & Co. Limited, Rowsley Works, Reddish, near Stockport. It is simply cut to size, the backing paper released at one edge and the film smoothed down with a soft cloth. The result is excellent and greatly enhances the appearance of the print or whatever is covered as well as providing complete protection. The material is supplied in rolls, 5 yd × 23 in. wide at 28/6 per roll, or 6/- per yard.



The vibratory motion in this machine gives improved finishing and colouring and is four to six times faster than the barrel method. Comparative examples are shown at right



Vibratory Mechanical Finishing

A new range of metal finishing machines use a vibratory motion in place of the rotary action of the conventional type barrel. The advantages claimed are faster and better descaling, deburring, radiusing, blending, smoothing and cutting down, britehoning and colouring. It is said that the new system is four to six times faster than the rotary barrel, the reason given being that in conventional barrelling the abrasive action takes place in a sliding zone several inches deep extending the width of the rotating cylinder. Beneath the zone little or no relative motion takes place between the components and the processing media, the mass being carried around in a position of repose until the point is reached where it commences to slide. With the new system the container holding the mass is subjected to a three-way vibration which produces an overall rotary motion of the whole mass and, at the same time, movement of the individual chips in random directions.

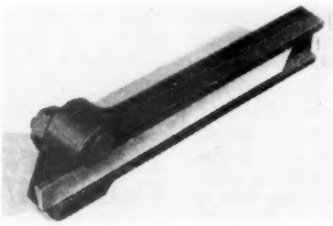
With the new method internal surfaces are treated as rapidly and as effectively as external surfaces, larger work loads relative to capacity can be accommodated, and the machines have an open head container so that visual control of progress and process is possible.

The development engineers of Roto-Finish Limited, 39 Park Street, London W1, have been working for some time on the development of a range of vibratory action machines with features and capacities suitable to European industries. They are also developing a two-tank vibratory machine which it is claimed has further advantages over the single tank type.

Wharton-Vilver Lifting Platforms

A wide range of Swiss-designed electro-mechanical lifting platforms is to be manufactured in Britain by Wharton Crane & Hoist Company Limited, of Reddish, Stockport. Extensively used on the Continent, the platforms have innumerable applications. Four standard models together give a capacity range of from a few pounds to 15 tons and height of lift of a few inches to over 16 ft. Simple modifications permit almost any requirement to be met.

The Wharton-Vilver platforms, being of simple electro-mechanical design, are highly adaptable. The small models, for example, often require no excavations. In some cases an excavation of only four inches or less is required. Special safety devices, exclusive to the equipment, are built in.



CUTTING-OFF TOOL HOLDER.—An addition to the existing range of Eclipse cutting-off tool holders, this $\frac{5}{16}$ in. (8 mm) capacity holder meets the demand for a small cutting-off tool holder on small lathes. The seating of the holder and the inclined head of the cotter bolt are both designed to ensure that the cutting-off tool is held rigidly in the correct position. It is supplied complete with a box spanner and an Eclipse H_3 cobalt H.S.S. hollow-ground cutting-off tool, $\frac{5}{16}$ in. wide × $\frac{1}{16}$ in. thick × 3¼ in. long, by James Neill & Company (Sheffield) Limited, Sheffield, England

Electrodes for Maintenance

Cobalarc electrodes, added by Quasi-Arc Limited, of Bilston, Staffs to the existing group of seven Duroid electrodes provide a complete range of hard facing products which can be applied to almost any type of plant subjected to wear.

The six types of Cobalarc electrode are graded according to the properties of the deposit, with resistance to maximum abrasion at one extreme and maximum impact at the other. In between, the deposits combine varying degrees of impact and abrasion resistance as well as resistance to corrosive liquids, oxidation, etc. The deposited alloys include tungsten carbide composites, chromium-carbide austenitic irons, cobalt and nickel base alloys, and martensitic, pearlitic and austenitic steels. Fields of application for these products include the quarrying, dredging, earth-moving, mining, brickmaking, cement, iron and steel, chemical, gas and power industries, and many others.

Diameters of the tubular Cobalarc electrodes go up to a maximum of $\frac{7}{16}$ in. and special moisture-proof coverings enable them to be stored under any conditions. The electrodes can be used with any conventional a.c. or d.c. welding power source and are equally suitable for use in shops or on site

Dust Extraction at Harwell

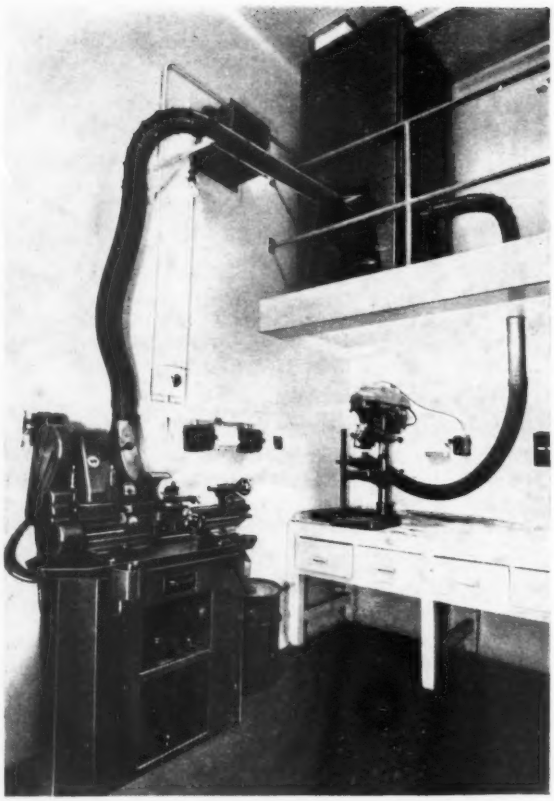
Dust extraction, as elsewhere, plays a large and essential part in the activities of the atomic energy field. The accompanying illustration shows a unit dust collector from the standard range of dust control equipment made by Dallow Lambert & Company Limited, of Thurmaston, Leicester. It controls the dust created by the lathe on the left of the picture, and also a drill used in the testing of parts brought from a reactor. Extraction from the lathe is very nearly absolute, whilst the drill hood is arranged for collecting airborne dust only. This hood, being connected by a flexible pipe to the unit dust collector, can be moved about and used as a cleaning nozzle. The dust entrained into the collector is arrested on the surface of the fabric filter pads, whilst the clean air passes through the fan outlet. The dust dislodged from the filter surface by a mechanical shaking device, is slightly radio-active and is collected in a polythene bag within the collecting bin to facilitate safe removal. The unit itself is checked regularly for radio-activity.

Vacuum Removal of Toxic Dust

At the recently built Springfields Works of the United Kingdom Atomic Energy Authority the handling of toxic dust has required special consideration. In this plant, equipped on a massive scale, six separate vacuumation systems have been installed by the British Vacuum Cleaner & Engineering Company Limited. These are essentially vacuum cleaning systems designed to remove surface deposits of dust and powder. They are especially notable for their successful employment of a unique cyclone method, which is not only efficient but ensures disposal of "hot" dust with the maximum degree of safety.

Dusts created at Springfields Works possess various properties, and it was essential for a number of reasons that these should be collected and neutralized with the greatest possible speed. The installations needed unusually careful planning, and were designed to two different arrangements to meet the layout of other plant and services. One of these systems covers 26 collection points and the capacity of the plant allows up to eight points to be used or open to suction at any one time.

Undoubtedly the most interesting fact about these installations is that, due to the nature of the powders and dusts collected, no accumulation of dust is permitted in any dry state. This condition, of course, precluded the use of conventional dust separators with fabric filters. To deal with the immediate collection of dust from the pick-up points by this method, high efficiency cyclones were introduced, which incorporated a unique wetting and dust-arresting feature. This feature operates most successfully and tests have indicated that the collecting efficiency of these units is virtually 100%. The dust, when picked up through the cleaning nozzles, is precipitated in the cyclones and held by the wet sump. This means that the whole of the inter-connecting pipework system, which is normally a dust conveying line, is employed purely for the passage of air, being completely free from dust particles. The dust is also collected in sealed boxes in which certain production processes are carried out. To handle this problem with the greatest degree of economy of suction power, automatic closing valve tools are retained in the boxes, and are handled by operators through glove ports.



Very nearly complete dust extraction is secured with the installation seen here. The lathe and drill are used in connexion with the testing of parts brought from a nuclear reactor

As a safeguard, secondary cyclones are incorporated in the systems, being located adjacent to the air exhauster units. These para-cyclones are of a high efficiency type, comprising multiple units within a single housing above a dust storage receptacle with wet sump. The air exhausted by the BVC units is conveyed to the main air extraction ducting.

A second vacuumation system has a similar function, but in this case, due to the nature of the powders and dusts handled, the wet sump feature of the primary cyclones gives rise to the development of gas. To overcome this condition and to prevent pressure build-up during operation, explosion vents are incorporated above each primary cyclone. To ventilate each cyclone, the inlets and suction control valves and the outlets are arranged with pilot holes, these ensuring that when the primary cyclone is isolated from the suction lines, there is a small air throughput to disperse any gas accumulation.

Portable Contamination Monitor

A new compact all-transistor monitor which offers unique facilities for detecting radioactive contamination has been produced by E.M.I. Electronics Limited. Known as the E.M.I. portable contamination monitor Type 1, the instrument employs the company's dual phosphor technique, and can be used for monitoring radioactive contamination on benches, clothing, and

similar objects. All-transistor circuitry enables the instrument to be operated for long periods from a battery supply.

The dual phosphor technique enables both alpha and beta contamination to be monitored simultaneously. Separate distinctive tones are provided for alpha and beta either on headphones worn by the operator, or a built-in loudspeaker.

The new monitor provides high accuracy over a wide temperature range (0° C to 45° C), and by using a single switch it is possible to monitor the sum of alpha and beta contamination, beta contamination alone, or just alpha contamination. This information in the form of counts per second is displayed on a meter covering the range 0–5000.

A high-pitched tone indicates alpha contamination and a low tone beta. Both notes are heard when alpha and beta are monitored. When the type of contamination has been identified an accurate check can be made on either the alpha or beta positions. For monitoring very low alpha activities an electro-mechanical register is included to give a more accurate display at rates below about 6 per sec.

The overall dimensions of the units are 11½ in. × 8 in. × 8½ in., its weight approximately 11 lb and power consumption ¾ watt.

Low Energy Gamma Emission Detector

To detect plutonium at maximum permissible body burden level or even less, Plessey Nucleonics Limited have developed a mains or battery operated portable detector, the P.N.I. 1080. This instrument is essentially a detector of low energy gamma radiation.

As well as being capable of detecting minute amounts of plutonium 239 in the human body, with slight modification and recalibration the instrument can also detect the presence of americum, a radioactive substance which will be contained in the plutonium manufactured by reactors in Britain. With another slight modification, the 1080 can detect uranium 235 which also emits low energy gamma rays. Yet another possible use of the instrument would be in the detection of plutonium 239 after a nuclear weapon accident.

The complete equipment consists of a detector probe connected by up to 6 ft of cable to an indicating unit.

The probe consists of a thin, thallium activated, sodium iodite scintillator mounted on the end of a multiplier photo tube. A chain of resistors is mounted on the inside of the probe in order to provide the correct potential on the dynodes and a cable matching network ensures optimum signal pulse transfer from the probe to the indicator unit. For hospital use the probe may be enclosed in a polythene container.

The indicator unit consists of a pulse amplifier, a pre-set but adjustable single channel pulse amplitude analyser, a variable and stabilized E.H.T. supply for the photo tube, and a display system. All circuits in the indicator unit use transistors.

Sensitivity of the instrument for direct plutonium radiation is 15 c/s per microcurie and about 0·2% of this figure for background radiation. Maximum permissible body burden of plutonium located at one point gives about five times the background count through 1 cm of human tissue.

Radiation Resistant Rocol Lubricants

Recently published data on the radiation resistance employed in nuclear power stations show that greases used in the charge machine, adjacent to the magazine, will be in the position of maximum radiation owing to the gamma rays emitted by used fuel elements. The minimum satisfactory standard therefore considered for lubricants in this situation is a capability to withstand 3,000,000 rads (3×10^6).

Rocol Molytone 265 grease, manufactured by Rocol Limited, Swillington, near Leeds, England, the manufacturers of Rocol Molytox, the first lubricant to be employed in commercial nuclear power reactors and to lubricate the control rod bearings at Calder Hall, has withstood irradiations of 7,000,000 rads (7×10^6) without deterioration and is, therefore, quite suitable to be used for charge machine lubrication.

Rocol Molytone 265 grease is now under test for extended periods of radiation in order to investigate its suitability for extending the service intervals and for its use in mechanisms closer to the reactor.

Rocol molybdenized lubricants have been employed for the lubrication and assembly of equipment subject to the highest radiation intensities for several years.

Recently Rocol anti-scuffing paste and Rocol Molytox Plus have been shown to be "compatible" with nuclear reactor components.

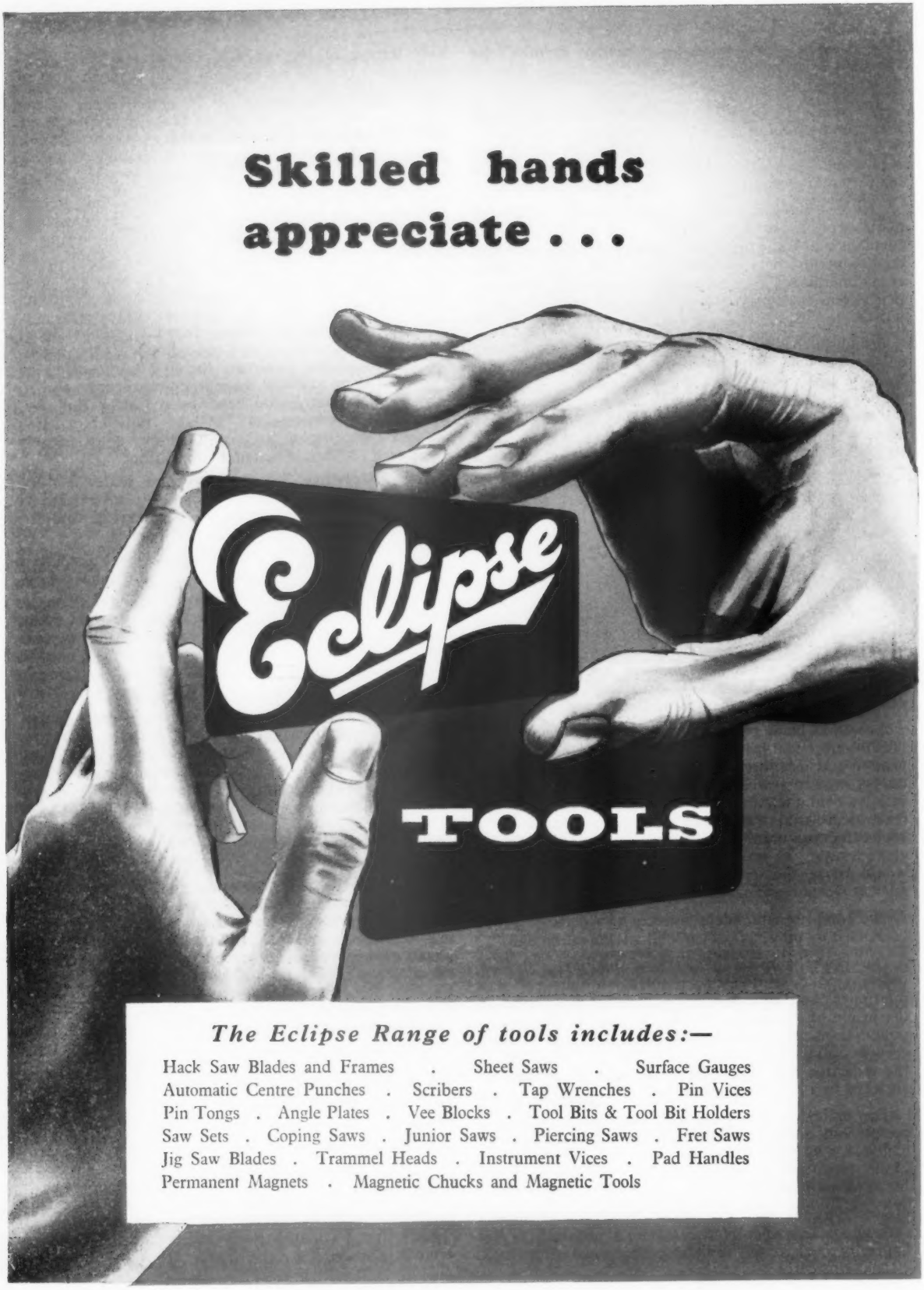
Nuclear Reactor 'Merlin'

The Merlin reactor inaugurated in November by His Royal Highness the Duke of Edinburgh, is Britain's first privately owned research reactor, for scientific research. It was built by the A.E.I.–John Thompson Nuclear Energy Company Limited, who are also building the 275 MW nuclear power station at Berkeley in Gloucestershire. The reactor was first made critical in July this year and the power is gradually being increased to its maximum of 5 megawatts.

'Merlin' is a most important research tool of the A.E.I. research organization. The programme for the reactor covers both fundamental and applied aspects of reactor research and will provide information about the metals used in nuclear power reactors, reactor safety and the effects of radiation on materials. The Universities of London, Reading and Southampton and certain Polytechnics are to use the reactor for the instruction of senior undergraduate and post-graduate students.

At the opening ceremony an underwater closed circuit television camera, specially designed by E.M.I. Electronics Limited, enabled the Duke to observe activity inside the reactor.

This camera, which is 30 in. long, 3½ in. dia, and enclosed in a pure aluminium water-tight housing, is a permanent part of Merlin's equipment. In addition, a standard E.M.I. camera has been mounted above the reactor, on the second floor of the reactor hall. This provides a continuous view all around Merlin, and ensures that no unauthorised staff are near the reactor when it is in use.



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Jig Saw Blades . Trammel Heads . Instrument Vices . Pad Handles
Permanent Magnets . Magnetic Chucks and Magnetic Tools

Proceedings of the Second United Nations Conference on the Peaceful Uses of Atomic Energy. Vol. 8, Nuclear Power Plants, Part 1. Geneva, United Nations. London; H. M. Stationery Office. £5 net (by post £5 2s. 6d.). 584 pp. $8\frac{1}{4} \times 10\frac{7}{8}$ in.

The appearance of information on nuclear energy has been intermittent and miscellaneous. Industry generally is interested in having information on non-military uses and the 33 volumes of proceedings of the Geneva Conference certainly offer the first comprehensive and systematic collection. The first volume to appear is No. 8, on nuclear power plants. It contains seven papers on experience with nuclear power plants, sixteen on uses other than the generation of electricity, and twenty-one on plans for the construction of plants.

The operating experiences described concern a number of different kinds of reactor, some of full-scale and others for experimental purposes. The treatment varies greatly, but taken all together the papers give a quite intimate picture of what has to be done to get a reactor into commission and to keep it working.

Marine propulsion has an important place in the papers dealing with uses other than electricity generation, and here the present position is reflected in the mixture of the actual with the projected; there being, perhaps naturally, more design information in the projects and more description of existing detail in the factual accomplishments, the latter including recognizably real drawings of details as well as photographs. District heating and house heating are the subjects of two Swedish proposals; these stations are being built in the rock. The provision of heat for industrial processes is an important use, and one which has received a good deal of attention in the United States. Clearly, if a great heat consuming unit can be supplied without the movement of great quantities of fuel an important degree of independence is secured which alone should be of economic benefit. The chemical industry offers some direct applications, particularly in nuclear radiation for promoting chemical reaction by the deposition of the energy of fission recoil fragments upon the chemical reactants. Taking another view of what is presented in the book, explosive properties of the nuclear reaction are not all of a military nature: controlled explosion can be of the greatest use in civil engineering work; and there is the further possibility of getting nearly 100% of the heat and power from the fuel by containing the energy of the explosion with no radiological hazard and at small pressure.

The plans for the construction of nuclear power plants include the re-design of Calder Hall; and the Hunterston, Hinkley Point, Bradwell and Berkeley Stations, all in course of erection. Plans come also from many other parts of the world—Canada, Czechoslovakia, U.S.A., France, Italy, Russia and Belgium. The contributions all offer considerable detail and data. The book is a massive collection of valuable material. It is, of course, presented as it was given to the conference and is therefore not at all like a textbook. It is possibly the most authoritative source which is readily available at the present time and will be invaluable to the large numbers of engineers engaged upon various phases of nuclear work.

books

History of the British Steel Industry from 450 B.C. to A.D. 1775. By H. R. Schubert. London, 1959; Routledge and Kegan Paul Limited. 60/- net (by post 61/9). 445 pp. $6 \times 9\frac{3}{4}$ in.

There are pretty clear indications of iron being worked in Britain well over 2,000 years ago, and there are remains of iron furnaces which are not much short of that age, showing that iron was made on some scale in those far off times. Steel was also made, presumably by increasing the furnace temperature, using more charcoal and keeping the air blast off the metal; certainly there are slags which bear this out and there are some relics with high carbon content. By Roman times there were 34 "ironworks" in operation in Britain, and in the Anglo-Saxon period which followed, English cutlery "attained such a standard of refinement and perfection that specimens were sent as special gifts abroad". The literature of this period provides evidence of steel being made, and of "steeling", the conversion of soft iron into steel by cementation. The industry gradually recovered after the destruction caused by the Norman Conquest, but it was not until the coming of the Cistercians in the 12th century that real expansion began, and this was in the north, whence much of the industry was finally to settle. Thereafter the demand for iron was increased by the demand for arms until a shortage of charcoal caused by clearing the forests for agriculture produced a crisis which was overcome eventually by the use of mined coal. After this in medieval times, it seems that the industry became diminished so much as to require steel to be imported in large quantities from the Continent. Nevertheless it was at this time that mechanization was introduced, in the form of water power. The blast furnace first made its appearance in Britain about 1500, and then began a new period in the history of British ironmaking. Sussex developed rapidly as the main centre in the first half of the 16th century, and expansion into Wales, the Midlands and the North followed. For a time the history of the industry was largely the history of the blastfurnace except for the introduction of refinements and secondary processes, until the next major change, brought about by the use of coke in the 18th century, and the introduction of the steam engine. "By the year 1850 this country was producing half the world's iron"—so ends this most interesting book. We have done no more here than indicate very broadly the events it covers, but the text contains many detailed studies of particular phases and developments, and illustrations from old documents. In the context of the present time the book is a light illuminating the relatively small but brilliant gem from the facets of which have grown the vast ramifications of the industry as we know it today. It is worth knowing this and the book conveys it well.

Trade Union Law. By H. Samuels. London, 1959; Stevens & Sons Limited. 17/6 net (by post 18/2). 108 pp. $5\frac{1}{4} \times 8\frac{1}{2}$ in.

This well-known book now appears in a sixth edition, and in its new form takes account of the Terms and Conditions of Employment Act, 1959, and includes further matter on such topics as collective agreements, strikes, restrictive practices, trade union rules, procedure, picketing, registration, disciplinary powers, and

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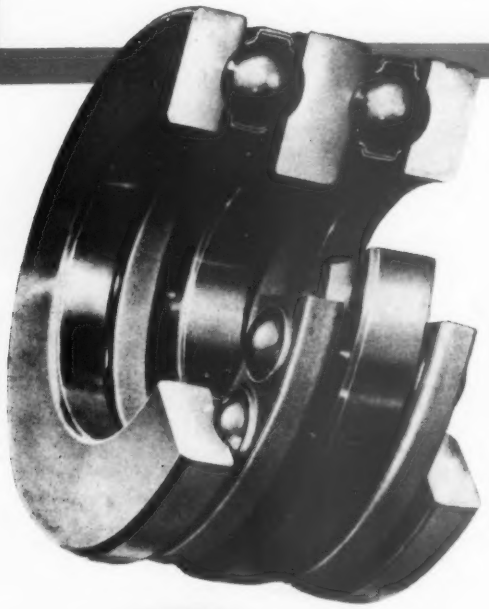
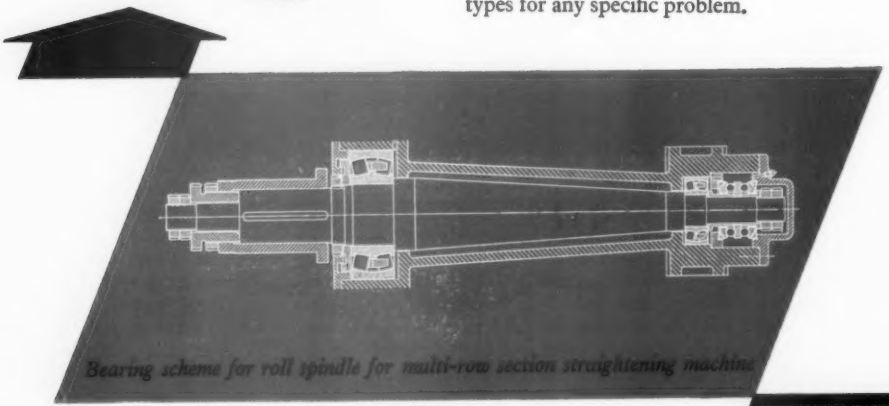
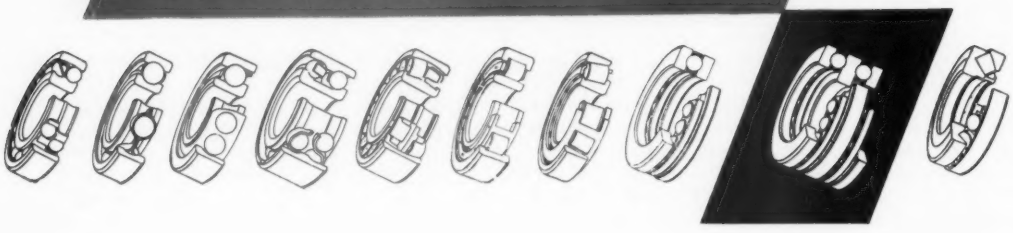


Where exclusively axial loads are to be dealt with acting in either direction, the double thrust ball bearing may be used. This bearing has two rows of balls, one for thrust in each direction. The centre ring is the shaft ring in metric sizes ; the housing rings may have either a flat or sphered seating. In inch sizes the centre ring is the housing ring.

This is one of the ten variants of the four basic rolling bearing types ; Skefko is the only British manufacturer making all four and can therefore offer completely unbiassed advice on the choice of bearing types for any specific problem.



Bearing scheme for roll spindle for multi-row section straightening machine



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disputes. There is a complete Table of Cases and another of Statutes. The author begins with a brief history of the subject and then goes on to outline the legislation and discusses definition and classification, and also the advantages of registration. Who may not be members of trade unions is then explained and the circumstances of expulsion examined. The contracts of trade unions and in particular the position of unregistered unions and unenforceable contracts and also the matter of collective agreements are discussed, and following this the author treats of civil wrongs outside trade disputes, intimidation, inducement of breach of contract, and conspiracy; and then goes on to consider these questions where there is a dispute, and with them such matters as acts in contemplation or furtherance of a trade dispute, and strikes and lock-outs; and to criminal conspiracy and intimidation. The final chapters treat of the rules of trade unions, the politcal fund, the registration of a trade union, property and liabilities of trade unions and such matters as amalgamations, dissolution and nominations, and civil and criminal proceedings. An appendix gives the texts of the various legal forms relating to trade unions.

Principles and Use of Surveying Instruments. By J. Clendinning. Glasgow, 1959; Blackie & Sons Limited, 25/- net (by post 26/1). 205 pp. $5\frac{3}{4} \times 8\frac{1}{2}$ in.

This is a particularly informative book for the author takes the view that the surveyor should be able to adjust and correct his instruments as well as use them. Thus in addition to comprehensive descriptions of the various instruments and detailed instruction in their use, he provides his reader with the knowledge requisite for keeping his instruments in trim, which by the very nature of surveying work is very valuable. Every kind of instrument is dealt with, from the chain to the photo-theodolite and the wedge telemeter, and including the various compasses, sextants etc., and even the nautical sextant. There is a companion book by the same author, "Principles and Practice of Surveying", and the two together provide the essential theory and practice in plane surveying commonly required by civil engineers: indeed the two texts provide all that is required by the A.M.I.C.E. examination in surveying.

Electro-technology for National Certificate Courses, Vol. III. By H. Buckingham and E. M. Price. London, 1959; The English Universities Press Limited. 16/- net (by post 17/2). 361 pp. $5\frac{3}{4} \times 8\frac{3}{4}$ in.

This third volume completes a series so far as an S3 year in an Ordinary Certificate Course is concerned. It follows on from the end of the second volume and begins with armature windings of d.c. machines and goes on to the characteristics of d.c. machines and their operation, electric and magnetic fields, electric circuit theory, polyphase a.c. systems, transformers, rotating fields, conversion of a.c. to d.c., electronics, complex waves, and some economic factors which require the attention of the student of electro-technology. Some tables of essential data are included at the end of the book where there is also a list of the experiments described at various places in the text.

New Standards

High strength friction grip bolts for structural engineering. Part 1: General grade bolts (B.S. 3139: Part 1:1959). Price 7/6.

This 32-page publication provides for one grade of quenched and tempered high strength friction grip hexagon head bolts and for their associated nuts and washers. Dimensions are given for a range of nominal sizes from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. inclusive, and data in the tests are "keyed" to annotated diagrams. Mechanical properties are specified, as are tests, inspection procedure and marking provisions.

The designation 'high strength friction grip bolts' has been adopted to distinguish the product from other types of high tensile bolts by indicating the mode of application.

Recommendations on use of the bolts are in course of preparation. They will in due course be issued as a British Standard.

Investment castings in metal. Part 1: Carbon and low alloy steels (B.S. 3146:Part 1:1959). Price 6/-.

The first part of a new British Standard for investment castings in metal has now been produced to fulfil the needs of industry in this expanding field. Castings made from carbon and low alloy steels are the subject of this first part; further parts to be published later will deal with higher alloy steels and special temperature steels. Castings of the type specified in this new standard are those the manufacture of which involves an expendable pattern using refractory slurry; shell moulding is thus excluded. The first section surveys general requirements and specifies the process, identification of the casting, procedure for testing mechanically and to destruction, and arrangements for repairing castings. The second section gives specific requirements for twelve different types of casting, some of which are sub-divided into two or three grades. The chemical composition and mechanical properties of each are detailed.

Laboratory potentiometric pH meters (B.S. 3145:1959). Price 3/-.

This new standard specifies performance requirements for laboratory potentiometric pH meters. Its appearance is appropriate in view of the issue in recent years of standards for pH scale and for glass electrodes (B.S.'s 1647 and 2586 respectively) and it will in due course be complemented by a specification for deflection pH meters.

Among the performance requirements specified are those for calibration of scales, sensitivity, stability and input current. Other requirements relate to the temperature compensating device, auxiliary pH control, connexion to the glass electrode, and screening.

Meters which purport to comply with the requirements of this specification are required to be marked with its number, i.e., "B.S. 3145".

Dimensions of tapered roller bearings (B.S. 3134:1959). Price 5/-.

A reduction in the present large range of sizes of tapered roller bearings is the ultimate goal of this 17-page specification. Intended as a guide to manufacturers and to users in the choice of bearings of both inch and metric sizes, the new publication contains 14 dimensional tables, the majority of which are presented in association with "keyed" diagrams. The dimensions in all but two of the tables conform to the proposals submitted for the preparation of an ISO international recommendation.

British Standards Institution, 2 Park Street, London, W1.

CUT HERE

Light-Sensitive Cells

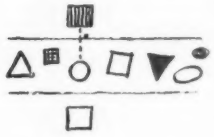
What are light-sensitive cells? They are devices which can sense and measure changes in the level of light or, in some cases, respond to the quality of light falling on them. There are various types of cell and each has its particular field of use. One of the best known is the photo-electric cell.

What can light-sensitive cells do? A change in the amount of light falling on the cell can cause a switch, relay or counter to operate. Alternatively, the direct indication of the light intensity can often allow some other factor to be determined and, if required, controlled. They are reliable and require little maintenance. Careful installation, as with all types of equipment, gives a good reward.

How can they be used? These cells have many applications in industry, for controlling processes, for inspection and measurement, for sorting material and for safety purposes:

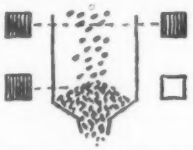
Counting

Where objects on a conveyor belt are too soft or light to operate a direct mechanical counting device, where they are too delicate or freshly painted to sustain physical contact or where the articles vary in size, a light-sensitive cell can be used. This counts the objects by interruption of an appropriately sited beam of light.



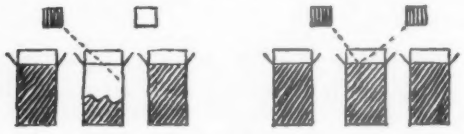
Hopper or Tank Level Control

Many forms of feed can be accurately controlled by light cells. One important one is for controlling the input to a hopper of fluid solids such as sand or peas. Here, two horizontal light beams are required: the upper, when interrupted, indicates that the hopper is full and stops the supply; the lower, when it ceases to be interrupted, indicates that the hopper is nearly empty and restarts the flow.



Package Content

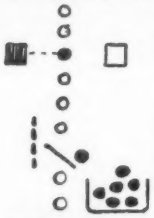
The level of powder in packages can be checked with light cells. The cell is so positioned that when the



powder is up to the required level, the light reflected from the surface of the powder is picked up by the cell and causes the carton to be accepted. If not, it is rejected.

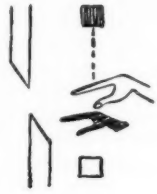
Colour Sorting

The quality of many articles can be gauged by their colour—seeds and nut kernels, for instance. The objects are fed into a tube by means of a vibrator pan and fall into the beams of three equally spaced light cells which scan them from all sides. If the object is acceptable it falls into a chute carrying it to one conveyor; if its colour is bad it is deflected as a reject.



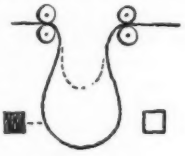
Guillotine Guard

Light cells for guarding a guillotine or power press should be used only as a supplement to a mechanical guard or where the latter is impracticable. The interruption of a curtain of light by a hand stops the machine instantaneously.



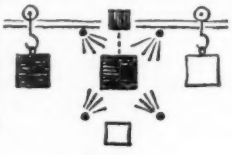
Press Feeding

Where the rate of feed of strip metal must be suited to a varying speed of acceptance by a press, a loop of the strip is allowed to sag between the feed and the press. When the loop reaches a predetermined depth a light beam is interrupted and the slack is taken up.



Processing Objects on the Move

Many articles are processed while on a conveyor line. For instance, where articles are to be sprayed while on the conveyor, the paint saved by stopping the gun between articles will make the device worthwhile. The same principle applies in a bakery to the spraying of baking tins with fat.



Automatic Door Opening and Closing

Doors can be caused to open or close by the interruption of a beam of light. This has its uses in such cases as control of doors on a heating oven or for the passage of vehicles in a factory. This is effected by a light beam on the side from which the approach is made (in many cases, both). When the approach beam is interrupted it opens the door which closes again after a given time interval.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association.

An excellent series of reference books are available (8/6 or 9/- post free) on electricity and productivity — "Higher Productivity" is an example. E.D.A. also have available on free loan a series of films on the industrial uses of electricity. Ask for a catalogue.

Issued by the Electrical Development Association
2 Savoy Hill, London, W.C.2

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BUSINESS & PROFESSIONAL

Personal

KERRY'S (GREAT BRITAIN) LIMITED announce the appointment of **Mr. H. R. Peters** as assistant managing director. Mr. Peters joined Kerry's in 1950 and was elected to the board in 1953.

Mr. J. M. S. Coates, O.B.E., F.C.A., has been appointed to the board of George Angus & Company Limited.

C. C. WAKEFIELD & COMPANY LIMITED announce that **Mr. Philip W. Lake** has been appointed secretary and **Mr. M. Field** has been appointed assistant secretary of Edwin Cooper & Co. Limited.

Mr. J. E. Robson, M.C., of Samuel Osborn & Co. Limited, Sheffield, has been appointed to the board of the company.

Mr. C. F. Gimson has been appointed divisional assistant chief engineer, A.E.I. motor and control gear division, and **Mr. K. M. Fox, A.M.I.E.E.,** until recently in charge of Swansea office, has been appointed manager of industrial machines department, motor and control gear division. **Mr. D. N. Relf, M.B.E., A.M.I.E.E.,** has been appointed manager, industrial electronic apparatus sales department.

Mr. G. B. Perry has been appointed managing director of Axia Fans Limited, a member of the Hall-Thermotank group of companies. He has also been appointed a director of Vent-Axia Limited, and will retain his seat on the board of Thermotank Limited, with which company he formerly held the executive posts of director, engineering division, and general manager of its international products division.

BRITISH RAILWAYS EASTERN REGION announce the appointment of **Mr. J. C. Spark** as works manager, Doncaster and of **Mr. P. Gray** as works manager, Stafford.

Mr. T. Furness, secretary and a director of Thomas Robinson & Son Limited, the Rochdale engineering company, has been appointed a joint managing director of the company. **Mr. R. Hampson** has been appointed southern area representative to the seed cleaning, brewing and malting, and allied industries.

CHAMBERLAIN INDUSTRIES LIMITED, of Staffa Works, Staffa Road, Leyton, London E10, manufacturers of tube bending machines and hydraulic equipment, have appointed **Mr. G. E. Hart** as technical sales director of the company.

Mr. E. W. Tinsley succeeds Mr. W. W. Nicholas as midlands representative for Walker, Crosweller & Co. Limited, Cheltenham.

CROFTS (ENGINEERS) LIMITED, of Bradford, Yorks., announce the appointment of two additional representatives for the London area: **Mr. L. C. Blake** and **Mr. A. E. Peggs.**

Mr. F. J. Jervis, B.Sc.(Eng.), A.M.Brit., I.R.E., A.M.I.W.M., has been appointed as contracts manager of Nash and Thomspon Limited, Chessington, Surrey, England.

PHILIPS ELECTRICAL LIMITED announce the appointment of **Mr. A. B. Skevington** as branch manager at Nottingham. **R. Seers** has been appointed to succeed Mr. Skevington as area manager and **Mr. E. W. Clarke** takes over Mr. Seer's territory.

Mr. S. R. Howes, O.B.E., has retired from the board of The United Steel Companies Limited.

CARBIDE INDUSTRIES LIMITED, a member of the British oxygen group of companies, announce the appointment at their carbide and acetylene factory at Maydown, near Londonderry, of **Dr. T. W. T. Baillie, B.Sc., Ph.D.,** as production manager, **Mr. W. W. Ringland, B.Sc., A.M.I.Chem.E.,** as chief works engineer, **Mr. A. R. Robertson** as commercial manager, and **Dr. R. D. Thrower, B.Sc., Ph.D.,** as works research and development manager.

Mr. John E. Coleman, M.I.E.E., has relinquished his directorship and major share-holdings in Spesco Developments, Limited, which will in future be controlled by Imperial Chemical Industries Limited.

Mr. Charles Soukup, managing director of Richard Klinger Limited, has retired owing to ill health.

GEORGE ELLISON LIMITED announce the appointment of **Mr. D. L. Stokes** as technical sales engineer for Ellison products in the counties of Essex, Norfolk, Suffolk, Huntingdon, Cambridge and Isle of Ely. **Mr. J. Russell Smith, M.I.E.E.,** who has represented George Ellison Limited for many years will continue to act in a consultative capacity in this area, but will additionally, from January 1, 1960, undertake special duties for the company.

THE BRITISH MATERIALS HANDLING Division of The Yale & Towne Manufacturing Company announces the appointment of **Mr. John McIvor** as Scottish area sales manager and of **Mr. G. K. Frame** as Scottish area sales engineer. They both operate from East Kilbride.

Dr. Norman Loveless, who is a lecturer in psychology at Queen's College, Dundee, has been appointed as a consultant to Smiths Aircraft Instruments Limited.

Mr. G. G. Ballard has been appointed chief engineer of Elliott Nucleonics Limited, a subsidiary of Elliott Brothers (London) Limited, and one of the companies in the Elliott-Automation Group.

EDGAR ALLEN & CO. LIMITED announces the retirement of **Mr. C. Shaw,** manager of the traffic department for 46 years.

Mr. Keith Allison, a member of the conveyor and belting section of the Goodyear industrial rubber products development department for the past three years has been appointed industrial rubber products sales manager for the Goodyear Tyre & Rubber Company of India Private Limited, at Calcutta.

Mr. George Williams has been appointed project and development executive of the Wakefield Castrol group of companies. Mr. Williams was formerly head of the Castrol Motor Oil International Racing Organization and is succeeded in this position by **Mr. James Hill.**

Dr. F. Llewellyn Smith, M.Sc., M.I.Mech.E., and **Mr. I. W. Macdonald, M.A., C.A.,** have been appointed part-time members of the National Research Development Corporation.

Obituary

WE regret to record the death of **Mr. Frederick Herbert Parker,** engineering manager, of Fairey Aviation Limited. Mr. Parker was responsible for the engineering of many famous Fairey aircraft including the Gannet prototypes, the record-breaking Fairey Delta 2 and the Rotodyne.

WE regret to record the death of **Mr. E. Philip Jenkins,** a director of Robert Jenkins & Co. Limited, Rotherham. For the past twelve years Mr. Jenkins represented the company in South West England.

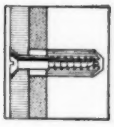
WE regret to record the death of **Mr. W. J. Wood,** chief assistant for the organization of the Metropolitan-Vickers Works School, with responsibility for recruitment and selection of craft apprentices. With almost 40 years of work in the education department Mr. Wood was known to thousands of M-V trained engineers in almost every part of the world.

WE regret to record the death of **Sir Myers Wayman, K.B.E.,** who succeeded Lord Nuffield as president of The Institution of Engineering Designers in May this year, after serving as a vice-president since 1951. Sir Myers was a Freeman of the City of London and Deputy Lieutenant of Durham County.

MODERN MATERIALS NEED MODERN METHODS

Old-fashioned fixing methods are *always* wasteful, and often enough entirely inadequate for modern materials. Whatever the material—brick or glass, solid or cavity—you'll make absolutely firm screw or bolt fixings many times faster with Rawlplug Fixing Devices and Tools.

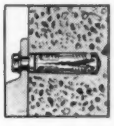
SCREW FIXINGS



RAWLPLUGS for neat firm fixings in brick, stone, etc. Rotproofed and waterproofed for use in all climatic conditions. All screw sizes up to ¾" diameter coach screws.

Rawlplug WHITE BRONZE PLUGS for fixings subject to very high temperatures, such as the outer brick coverings of furnaces. Also for underwater fixtures.

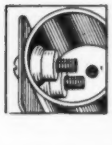
BOLT FIXINGS



RAWLBOLTS for bolting down machines—a rock-firm *dry* fixing that grips by expansion. No cold chiselling, no waiting for cement to harden. Sizes up to 1" bolt diameter.

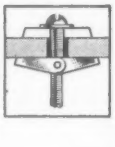
Rawlplug BOLT ANCHORS for bolting down in extremely wet or corrosive situations. Caulking completely seals the anchorage. Also for anchoring Diesel Generators, Power Hammers, etc.

CAVITY FIXINGS



Screwed up from the front, the amazing RAWLNUT forms its own rivet head behind the material—airtight, watertight, vibration-proof, squeak-proof. For all thin or hollow materials.

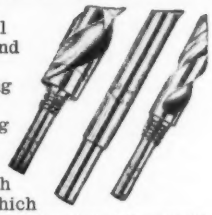
Rawlplug SPRING TOGGLES for ceilings of lath and plaster, plasterboard, etc. The Toggle springs open behind the material, spreading the load over a wide area.



RAWLPLUG DURIUM
THE FAST DRILLING, SILENT MASONRY DRILL— AND THE MOST DURABLE

With its ultra-tough, almost diamond-hard Durium tip, and its patented rapid-helix flute to force out spoil and prevent clogging, Durium drills brick, tile, cement, slate, marble, etc. with a speed of penetration that is truly amazing.
It is this same toughness of the Durium tip, and the stronger backing given it by the specially designed flute, that gives a Durium Drill its astonishing ability to stand up to the abrasive action of masonry which so quickly ruins ordinary drills.
Only a Durium Drill has such sharp, silent, easy cutting accuracy, such amazing drilling speed, such sheer durability!

FULL RANGE—DRILLING LENGTHS UP TO 16" TOO!



Durium Drills are made for all sizes of Rawlplugs from No. 6 to No. 30 (i.e. drill cutting diameters from 5/32" up to 1") and also for Rawlbolts sizes C, D, E & G.
Durium Drills are also made in the Long Series to facilitate the work of laying conduits, cables, pipes, etc. Five cutting diameters (½" up to ⅝") are available in 6" drilling lengths; six cutting diameters (⅝" up to 1") are available with threaded ends to take extension rods which provide for overall drilling lengths of approximately 12" and 16".

DURIUM *GLASS* DRILLS

These high-efficiency drills can be used in a wheelbrace or suitable electric drill. 9 cutting diameters, from ⅛" up to ¼".

BY HAND OR POWER

Durium Drills can be used very successfully in an ordinary wheelbrace, but where drilling is carried on fairly regularly, or on a large scale, a Rawlplug R.P.1. Slow Speed Electric Drill is a time-saver that will pay for itself over and over again. With full load speed of 450 r.p.m. this easy-to-handle power tool will give quite sensational results with Durium Drills.

FREE RE-SHARPENING SERVICE

When, at long last, your Durium Drill begins to lose its keenness, return it to us with the complimentary voucher supplied with it, and we'll re-sharpen FREE!
Durium Drills are sold in the bright orange and blue metal container clearly marked Rawlplug Durium. Look for the name DURIUM on the drill shank—no other is a genuine DURIUM Drill.

RAWLPLUGS

RAWLPLUG FIXING DEVICES AND TOOLS

21 different types of fixing devices for speed and strength

Write now for illustrated literature containing full details of Rawlplug Fixing Devices and the many high performance Rawlplug tools (hand, electric and pneumatic).

THE RAWLPLUG CO. LTD., CROMWELL ROAD, LONDON, S.W.7

The world's largest manufacturers of fixing devices

We regret to record the death of **Mr. H. W. T. Mason,** formerly deputy manager of the London Office of Edgar Allen & Co. Limited. Mr. Mason represented the company from 1908–1914 in India and the Malay States.

Addresses

British Insulated Callender's Cables Limited have changed the address of their Northampton Depot which is now 18/22 St. George's Street, Northampton. The telephone number, Northampton 1860, is unchanged.

New offices at 23/24 King Street, London SW1 are now occupied by Dunlop. The offices, built on the site formerly occupied by the St. James's Theatre, have been named St. James's House. The company's head office, St. James's House, at 25 Ryder Street, London SW1, has been renamed Dunlop House.

Pollard Bearings Limited have recently opened a French branch office in Paris, the title and address of which is Pollard-Roulements, 98, Rue Truffaut, Paris 17E. (Telephone: MARcadet 09-10). Canadian Pollard Bearings Limited, Oakville, Ontario, the Canadian associate company of Pollard Bearings Limited, are opening a branch office in Montreal at 623, Decarie Boulevard, Ville St. Laurent P.Q.

The address of the Bristol branch office of The English Electric Company is now Equity and Law Building, 36/38, Baldwin Street, Bristol, 1. The telephone number remains the same (Bristol 27304), and the Domestic Appliance Service Depot remains at 155 Whiteladies Road, Bristol 8.

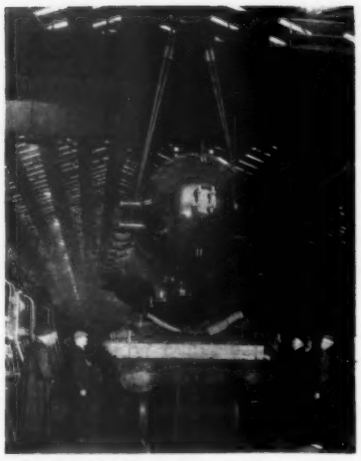
Ferodo Limited have opened new premises at 3 Condercum Road, Newcastle upon Tyne 4, Telephone Nos. Newcastle upon Tyne 39131/2. These premises replace the accommodation in Barras Buildings which the Company have occupied in the city for the past twenty four years.

Kayser Ellison & Company Limited have vacated premises at Brompton Road and have reopened in offices at 4 Pembridge Mews, Notting Hill Gate, W11, adjoining their London warehouse.

The London Area Sales Office of Northern Aluminium Company Limited has removed from Bush House to new premises at 50, Eastbourne Terrace, London W2. Telephone number Paddington 3281; telegraphic address Noralumin London.

Martonair Limited, manufacturers of pneumatic equipment, have formed a French company—Martonair S.A.R.L., under the management of Mr. Gerald Simon. The address of the company is 41 bis. Bld. Paul Vaillant-Couturier, Montreuil (Seine). Tel: AVRon 49-26.

Martonair S.A.R.L. will undertake the manufacture under licence of a large range of pneumatic equipment, and will work in close co-operation with Martonair companies in other Common Market countries.



MAMMOTH LOAD BY RAIL.—On October 23, in a private siding at Renfrew, this large boiler drum weighing 90 tons was loaded on a special railway truck designed and built for this class of traffic. The consignment was over 50 ft long with a diameter of more than 6 ft. Each phase of the 376 miles long journey and the train service had been plotted out in advance. Because of the special nature and exceptional weight of the load an operating goods inspector travelled on the train. The consignment was carefully watched throughout its transit until delivery to Uskmouth power station at Newport (Monmouth.) on October 28. The drum was manufactured by Babcock & Wilcox Limited, Renfrew

A new company, Hursant Electronics Limited, 13–14 The Mall, Ealing, London W5, to specialize in the application of electronics in industry and education, has been formed by Mr. D. C. Adams and Mr. R. C. Lever, former sales manager and chief engineer, respectively, of Hivolt Limited.

Business Developments

Trading agreements

Powell Duffryn Engineering Company Limited, Cardiff, have been appointed licenced manufacturer for the U.K. and Europe of the entire range of Dempster-Dumpster container handling vehicles and equipment.

The trading activities of The Power-Gas Corporation Limited, of Stockton-on-Tees, have now been taken over by two wholly-owned subsidiaries of the same address, i.e., Ashmore, Benson, Pease & Co. Limited, and P.G. Engineering Limited.

Mono Pumps Limited will in future be represented in Australia by a new subsidiary company, Mono Pumps (Australia) Pty. Limited. The chairman is Sir Giles Chippindall, G.B.E., and the managing director is Mr. G. H. Snow. Mr. R. Snape is secretary and director.

Company acquisitions

Murex Welding Processes Limited, Waltham Cross, Herts, have purchased the whole of the issued shares of Donal Ross & Partners Limited, Crawley, Sussex, manufacturers of mechanical aids to production. The latter company will continue to operate as in the past and under the same name and management.

Copperad Limited, manufacturers of heating and ventilation equipment of Colnbrook, Bucks., have acquired the entire share capital of the Manwood Miller Group of Companies.

Wilmot Breeden Limited, Birmingham, have acquired a majority holding in the French company, Autocoussin Dura, S.A., manufacturers of locks, window regulators, etc., for motor vehicles.

Agents and distributors

Stenor Limited of Richmond, Surrey, have appointed M. Silva, Campo das Cebolas 47, 1., Lisbon, as their new agents in Portugal.

Alfred Bullows Limited, Long Street, Walsall, have acquired the sole distribution rights in the U.K. for the complete range of Graco industrial equipment made by the Gray Company Inc. of Minneapolis, U.S.A.

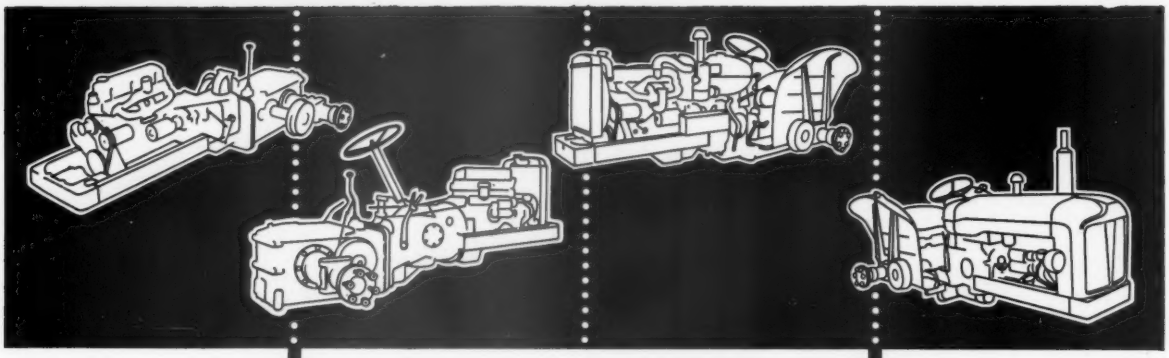
Firth Cleveland Limited will be represented in the United States by a new company, Firth Cleveland Incorporated, with offices at Lincoln Building, 60 East 42nd Street, New York. A new subsidiary of Firth Cleveland Inc.—Surform Incorporated—will be responsible in the U.S.A. for distribution of Surform and Surcut hand tools.

Neldco Processes Limited have been appointed sole agents for the Sterling Area for Krebs Cyclones.

Keelavite Hydraulics Limited, Allesley, Coventry, have appointed Holman Bros. (Pty.) Limited, P.O. Box 6218, Johannesburg, as their agent for the sale of hydraulic equipment in South Africa and Rhodesia.

Nash & Thompson Limited, Chessington, Surrey, have appointed A. R. Bolton & Company, 3a St. Vincent Street, Edinburgh 3, as their sole agents for Scotland.

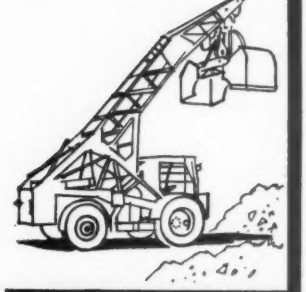
The name of Synthetic Carbon & Engineering Company Limited has been changed to Morgan Components Limited, in order to clarify the association with the parent company, The Morgan Crucible Company Limited, Battersea. Capacity at Stanmore has been enlarged and will be concentrated on the sales and production of all brush holders hitherto manufactured by The Morgan Crucible Company Limited and Synthetic Carbon & Engineering Company Limited. A wide range of brush holders has been manufactured by the two companies over the last 25 years and with the integration of technical and manufacturing experience it is planned to add to the range now offered: these will be marketed under the trade name "Morganite". Morgan Components Limited will continue to manufacture and supply a variety of metal contacts and associated metal assemblies, which were formerly supplied by the



Buyers looking for better equipment look for

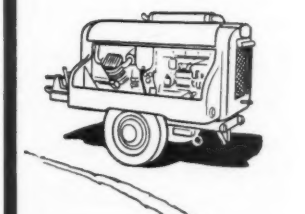
Fordson Power

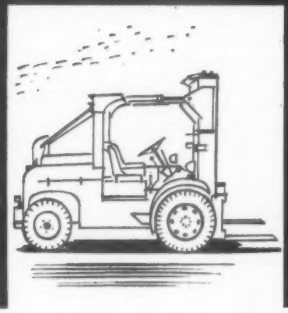
... because Fordson Power gives the stamp of reliability, ensures high output at low cost, and because it has the backing of the Ford world-wide service and spares organisation. There are Fordson Industrial Equipment Units in the 30-40 b.h.p. and 40-50 b.h.p. classes, in more than 100 different assemblies. Fit Fordson and you get all the benefits of quality mass production from Ford's famous Dagenham factory, the biggest producer of mobile power units. Fit Fordson, the unit tailor-made to your requirements.

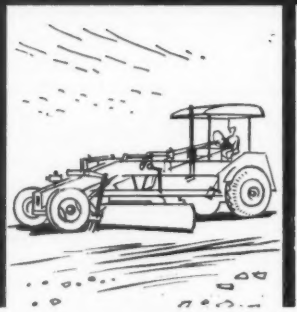


Wise buyers insist on

Fordson Power







INDUSTRIAL SALES DEPARTMENT · TRACTOR DIVISION FORD MOTOR COMPANY LIMITED DAGENHAM · ESSEX

Synthetic Carbon & Engineering Company Limited. Enquiries and orders for carbon brushes and carbon contacts, formerly supplied by the Synthetic Carbon & Engineering Company Limited should now be sent to The Morgan Crucible Company Limited, Battersea Church Road, London SW11. The grades of carbon used will be as previously supplied but the grade markings will conform to the Morganite series.

Film News

Industrial Electric Heating.—This film deals briefly with the theory, and at length with the practice, of electrical process heating of all kinds in most industries. It is designed for showing to factory managers and others whose technological experience is likely to be associated more with their own trade than with things electrical. It is in Eastmancolour and runs for 30 min. The film is available, on free loan, in both 16 mm and 35 mm from the Electrical Development Association, 2 Savoy Hill, London WC2.

Winding an Electric Motor.—This is the title of a colour film recently issued by the Brook Film Unit, a 16 mm sound production with a running time of 9½ minutes. The commentary is spoken by Richard Baker. The film gives a simple explanation of the basic functioning and winding of a normal three phase motor. Made particularly for use in technical colleges and schools, it will also prove useful to companies who operate training schemes for their own electrical apprentices.

Contracts and Work in Progress

WORTHINGTON - SIMPSON LIMITED.—Contract from the Central Electricity Generating Board covering the design, supply and erection of condensing plant for two 300 MW turbo generators for West Thurrock power station, Essex.

SOLARTRON ELECTRONIC GROUP.—The first two production models of the new "Space 30" analogue computer have been ordered by the British Thomson-Houston Company Limited, Rugby.

BROOKES (OLDBURY) LIMITED. (T.I. Subsidiary company).—Order from V/O Stankoimport, Moscow, for two double internal tube polishing machines complete with dust extraction equipment and ancillary equipment. Total value over £30,000.

GEORGE KENT LIMITED, Luton.—Instruments and controls for use on the first section of the City Council of Pretoria's new power station at Rooiwal, South Africa.

FERRANTI LIMITED.—Order exceeding ¼M. dollars placed by the Anaconda Wire & Cable Company of New York for large high voltage a.c. cable testing set.

THE ENGLISH ELECTRIC COMPANY LIMITED.—Order exceeding £½M. for the supply of diesel-generating equipment to the Karachi Electricity Supply Corporation, Pakistan.

BIRLEC LIMITED.—Annealing furnace for 100 ton steel forgings for The English Steel Company Limited, Sheffield, value over £65,000.

Vacuum furnaces for U.K. Atomic Energy Authority, value approximately £22,000.

£9000 order from Oy Vuoksenniska Ab of Finland for electric annealing furnace.

New Scientific Society

A NEWLY formed scientific society, the Society of Environmental Engineers, with offices at 42 Manchester Street, London W1, has been formed to provide a forum, by meetings, publications and visits, for the exchange of information and views among those engineers who are concerned with the development of equipment to withstand shock, vibration and other forms of environmental conditions, and who research in these fields. Membership and associate membership is open to scientists and engineers and sponsor membership is open to firms similarly concerned. Details may be obtained from the Secretary, The Society of Environmental Engineers, 42 Manchester Street, London W1.

Trade Literature

Expandite Jubilee

A brochure commemorating the 25th Anniversary of Expandite Limited, of Chase Road, London, NW10, describes the various products made by the company and their fields of application. Joint movement is found in every branch of engineering construction and consequently sealing to be done. The company has been very successful in developing suitable materials to solve a large number of such problems.

Shockless Acceleration

A card from Crofts (Engineers) Limited, Bradford 3, Yorkshire, illustrates the Crofts "free-space" type hydraulic couplings and drives which provide smooth transmission, overload protection, permit the use of smaller, cheaper motors and starters, and give longer machinery life. There is a full range of sizes available for powers up to 350 hp and dual types up to 700 hp.

Autocollimators

Autocollimators measure straightness, flatness, alignment, angular rotation and small linear displacements. Three instruments of the type made by Hilger & Watts Limited, 98 St. Pancras Way, Camden Town, London, NW1, are described in a new catalogue. Examples of their use are illustrated and include checking the slides of machine tools, measuring the diameter of fine wire, testing the straightness of a shaft, testing a circular table, and surface plate calibration.

"Duraglas" Glass Fibre Products

"Duraglas" products are designed to make the fullest use of the properties of glass fibre. It is available in both low and high alkali content, the former for high strength laminates and electrical applications and the latter for normal commercial moulding. A new comprehensive brochure issued by Turner Brothers Asbestos Company Limited P.O. Box No. 4, Rochdale, Lancashire, gives technical particulars of these materials, notes on the manufacture of glass fibre, and full details of "Duraglas" products. The material is produced in the form of fabric in various weaves, tapes, chopped strand for pressure moulding, chemically bound mat, woven and parallel roving, chopped roving for dough moulding, webbing and yarn. An instructive section describes the various moulding techniques. The brochure may be had on application to the Company at the address given above, or any of its branches.

P.T.F.E. Products

Polytetrafluorethylene is made in a number of useful forms by Turner Brothers Asbestos Company who have issued a booklet which illustrates the material in the form of tape, gland packings, solid gaskets, washers, discs, milled and slit envelope gaskets, machined components, expansion joints, and plaited packings. The booklet also sets out the mechanical and electrical properties of the material and gives dimensional particulars and ranges of the products. Copies are available from the address given above or from any of the company's branches.

Electr-O-Vane Control Unit

A leaflet from Honeywell Controls Limited, Ruislip Road East, Greenford, Middlesex, describes the Electr-O-Vane control unit, a precision power switch actuated by minimum force and travel. Snap action of the power relay occurs when a vane stops circuit oscillation by moving to a critical point between coils. The instrument can be linked to any moving member of machinery. A few applications are for exact weighing, precise limit switching, checking deflexion, counting without contact, and wear detection.

Eclipse Permanent-electro Magnetic Chucks

A new folder in colour shows very clearly how the new Eclipse permanent-electro magnetic chucks are constructed and how they operate. Graphs show the advantageous performance of the new chucks and tabular data is included of the range of sizes. The folder is obtainable from the makers of Eclipse tools, James Neill & Co. (Sheffield) Limited, Napier Street, Sheffield, 11.

(*Continued on page 497*)

From the Goodyear family tree

BELTING THAT TAKES A LOT OF BEATING

TRANSMISSION BELTS

CONVEYOR BELTS

V-BELTS

HOSE

FENDERS

Whatever material you want to move, whatever the conditions, you'll find the conveyor belt for the job in the Goodyear family tree! For abrasive coke or hot sinter . . . oily materials or sharp stone . . . food and coal . . . a 'job-designed' Goodyear belt is your best choice for longest, low-cost performance. Special features include: good troughing, high impact resistance and flex life, and resistance to mildew. Get in touch with Goodyear now for Britain's most comprehensive conveyor belt service.

- Tough cover compounded to suit job
- Breaker fabric between cover and carcass — where required
- Plies of close-woven cotton duck, or synthetic fibres mildew inhibited
- Skim coat between plies to increase flexibility, prevent separation
- Substantial edge cover to resist wear

GOODYEAR

THE GREATEST NAME IN RUBBER

The Goodyear Tyre & Rubber Company (G.B.) Ltd., Industrial Rubber Products Dept., Wolverhampton.

Cold Facts

A booklet of facts, figures and photographs recently published by Expanded Rubber Company, is full of useful information about insulation. Called "Onazote for cold storage", it is divided into four main sections: sub-zero stores, cold stores, cool stores and conditioning rooms, each section illustrated with pictures of Onazote installations. A brief appendix shows example of overseas installations. As well as information, the booklet contains examples of how to calculate heat transmission through various insulated structures and tables of conditions under which moisture could be deposited in the form of condensation.

Centrifugal Coolant Clarifier

The 3C coolant clarifier operates on the centrifugal principle and therefore removes non-magnetic as well as magnetic matter from the coolant. It is completely self-contained and has a vaned rotor revolving at high speed within which the foreign matter is deposited in a solid cake which can easily be removed periodically. A new illustrated catalogue (Publication No. 511) is available from the makers, Machine Shop Equipment Limited, Spenser Street, London, S.W.1.

British Petroleum Equipment

The 1959-60 edition of the composite catalogue of oilfield equipment manufactured in Great Britain, published by the Council of British Manufacturers of Petroleum Equipment, is a large volume of 894 pages of which 790 give detailed technical descriptions of individual firms' products and services, with many illustrations and charts. The remaining pages give particulars under some 2400 headings of the equipment manufactured by the 450 member firms. The price of the catalogue is £2-10-0 and copies are available from the council's offices at 2 Princes Row, Buckingham Palace Road, London, SW1.

Churchill Automatic Sizing

A new development of the Churchill BW plain grinding machine is the addition of the Churchill diminishing feed mechanism and automatic wheel truing and compensation together with the automatic control of the machine cycle by electric sizing gauge for plunge grinding. The machine thus becomes fully automatic—all the operations following a pre-set, controlled cycle until it is necessary tc renew the wheel. When wheels are changed provision has been made to give continuous upward power movement of the diamond by means of a push button. A similar movement for positioning the diamond downwards is also provided together with means for obtaining a single ratchet feed for picking-up the wheel face with the point of the diamond after fitting a new wheel.

Churchill Centreless Grinding Machine

The important features of the redesigned Churchill Model EC centreless grinding machine are outlined in a new catalogue issued by The Churchill Machine Tool Company Limited, Broadheath, Manchester. The improvements make for rigidity, accuracy and longevity and add to the capabilities of the machine, and its already high productive capacity can be further increased by an automatic infeed mechanism and hopper feed equipment. A patented quick-change through-feed workrest makes the machine quickly adaptable and enables small quantities to be ground as economically as large quantities. The machine will take wheels up to 8 in. wide.

Trade Literature

Plastics Component Bins

The latest moulded Kabi "Plastibox" component storage bins can be stacked, a considerable advantage to-day where space is at a premium. The bins are moulded in either high-impact polystyrene—inert to a wide range of chemical agents and resistant to most non-concentrated acids and oil—or in nylon, again resistant to acids and oil. They are practically unbreakable and will wear indefinitely. Details are given in a leaflet obtainable from Precision Components (Barnet) Limited, 13 Byng Road, Barnet, Herts.

Contact Welding Electrode

A new zircon iron powder coated electrode has been specially developed for rapid, trouble-free contact welding of all mild and low alloy steels in downhand, standing fillet and horizontal-vertical positions. The mechanical properties, X-ray qualities, and the extremely high impact values, which are in excess of conventional low hydrogen electrodes, obtained with the new Philips C/16, make it particularly suitable for the demanding conditions of nuclear engineering. A leaflet giving full technical and test data and chemical analysis is obtainable from Philips Electrical (Industrial Products Division), Century House, Shaftesbury Avenue, London WC2.

Plastics in the Chemical Industry

The increasing use of synthetic resins and plastics in the chemical industry is described in a new illustrated brochure. Because of their resistance to corrosion and abrasion, light weight and ease of fabrication, plastics materials are ideal for the construction of many types of chemical plant. They are also extensively used in the manufacture of protective clothing and as packaging materials for chemical products. The booklet illustrates a wide range of applications in each of these fields and indicates the special properties possessed by the different types of plastics materials which cause them to be employed. Copies of "Synthetic Resins and Plastics in the Chemical Industry" are available free of charge from Information Department, Distillers Plastics Group, Devonshire House, Piccadilly, London W1.

Six-inch Super Saw Kit

Bridges are offering good value in a new 6 in. saw kit which contains their $\frac{1}{16}$ in. Neonic drill, Nu-Rip portable saw with 6 in. blade, multi-purpose saw table, 6 in. combination saw blade, and instruction booklet—the lot for £19 2s. 3d., or £1 less than the sum of the separate prices. An illustrated folder is available from S. N. Bridges & Co. Limited, York Road, London SW11.

Heavy Duty TransVeyor

The TransVeyor ball assembly has now appeared in heavy duty form suitable for use in rolling mills, shipyards, atomic plants, etc. It has a capacity of 750 lb and consists of a 3 in. dia ball resting on a bed of small balls, the whole contained in a sealed assembly arranged for grease gun lubrication. The load carried can be as high as the unit capacity mentioned multiplied by the number of units in contact with the load. Shock load is catered for by cushion mounting. An illustrated leaflet can be had now from the makers, J. Collis & Sons Limited, Regent Square, Gray's Inn Road, London WC1.

Signalling Cable

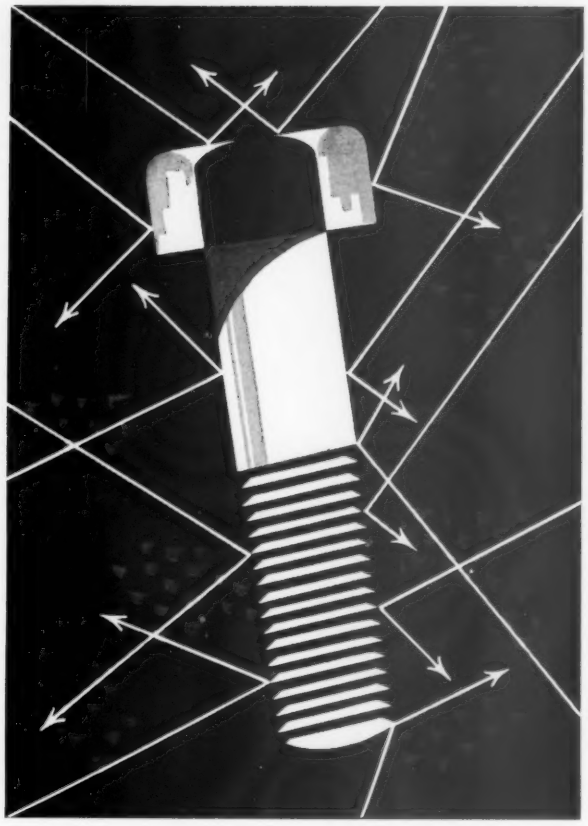
A particularly robust cable and coupler for bell signalling is described in a bulletin issued by Victor Products (Wallsend) Limited, Wallsend-on-Tyne. Intended primarily for use in mines, the cable consists of three strengthened electrical conductors embedded in a $\frac{1}{2}$ in. dia steel rope. Short lengths of this cable are connected by restrained type quick release plug and socket couplers in each of which is incorporated a push switch for signalling purposes which connects two of the conductors together. The push button is provided with a lock-in device.

Ferodo for Agricultural Machinery

Ferodo Limited, Chapel-en-le-Frith, Stockport, have published a new catalogue of friction materials and belts for agricultural machinery. It is principally concerned with farm tractors and combine harvesters, although it also includes for the first time data on a large number of motor lawnmowers and horticultural multi-purpose equipment.

Plug-in Master Controller

A compact joy stick type of controller for cranes and heavy industrial machinery generally is described in a leaflet issued by Allen West & Co. Limited, Brighton, 7. Particularly notable is its accessibility since



WHY FIGHT CORROSION

Most chemical firms in this country spend a good deal of time and money in preventing corrosion of expensive process plant. And to little purpose, for corrosion has an uncanny habit of defeating even the most careful measures.

What's the answer? Well you can economise most decidedly in one respect: standardise on stainless steel nuts, bolts and setscrews. Stainless steel stands no nonsense from most forms of chemical corrosion. It stays bright and clean throughout the life of the equipment.

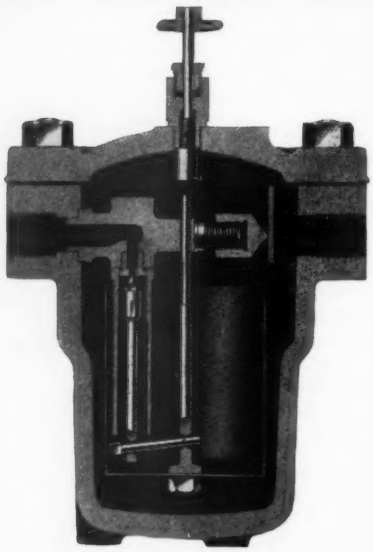
Nor need this be expensive. Stainless steel nuts and bolts from LANARKSHIRE are hot forged but bright finished—the cheapest production method by far. Naturally, base material is the best – EN58B or EN58J. And naturally, you can have ex stock delivery from LANARKSHIRE in sizes from ½" dia. upwards to B.S. 1083, 2708 and 1769. Studs and stud bolts also supplied.

Please write for monthly stock list from

LANARKSHIRE
BOLT LIMITED

HAMILTON · LANARKSHIRE · SCOTLAND
Tel: Hamilton 1241-4.

"The Lancaster"
REG^D TRADE MARK



COMPACT BUCKET TYPE STEAM TRAP

Specially designed to go in a small space yet to give a copious discharge. Will lift its discharge water 2 ft. for each 1 lb. pressure of steam. AUTOMATIC "AIR-VALVE" eliminates "AIR-LOCK." Fitted with NICKEL VALVE and SEAT.

THERE'S A STEAM TRAP FOR EVERY PURPOSE — OVER 70 YEARS' EXPERIENCE AT YOUR DISPOSAL.

We welcome your enquiries.

LANCASTER & TONGE
LIMITED
PENDLETON · MANCHESTER · ENGLAND

the interior of the controller is "plugged in" and can therefore be lifted out from above without undoing any connexions. The moving contact assembly is then easily removed sideways by slackening two screws.

Photo-electric and Electronic Controls

Numerous devices are illustrated in a new folder obtainable from Radioviser Parent Limited, Stanhope Works, High Path, London SW19. Instruments for counting and batching, print registration, level control, welding control and smoke detection are only some of them. The company specialises in electronic equipment and has extensive facilities for designing and building special controls for automation.

Auto-Klean Data

A new book of data for users of the well-known Auto-Klean filters is now available from Auto-Klean Strainers Limited, Lascar Works, Hounslow, Middlesex. It contains the information and data required by designers and engineers for dealing with filtration problems, and presents and gives detailed specifications and flow rates for the full Auto-Klean range as well as examples of installations drawn from numerous widely differing industries.

New Factories

Barnard Castle. Plans have been prepared by Clayton and Deas, High Row Chambers, Darlington, for proposed foundry additions for the Newgate Foundry Company.

Blaydon (Co. Durham). J. Roulstone Limited, Railway Arches, Pilgrim Street, Newcastle upon Tyne are to erect storage building and offices at Chain Bridge Road.

Chester-le-Street. The Artic Fuse and Electrical Manufacturing Company, are to buy 1,450 sq yds of land for extensions to their premises at Elizabethville, Birtley.

Jarrow. Sterling Foundry Specialities Limited, are to erect factory and offices north of Chaytor Street and Ellison Place. The architects are Newrick and Blackbell, 58 John Street, Sunderland.

Newcastle upon Tyne. Tyneside Tinprinting Works, Edgefield Avenue. Plans for extensions have been prepared by Cackett, Burns, Dick and McKellar, 21 Ellison Place.

South Shields. The Town Council is to spend £9,700 on the construction of a bus washing machine. The work will be carried out by Tarslag Limited, Bowesfield Lane, Stockton-on-Tees.

Tynemouth. Esso Petroleum Co. Limited. The architects for the erection of office block, canteen and kitchen at the large new oil terminal now being built are Cruikshanks and Seward, 196 Deansgate, Manchester.

R. S. Robson, 3 Longston Avenue, Cullercoats, Whitley Bay, is proposing the erection of a sports car factory, workshops, maintenance depot, garage and filling station at Burdon Main Row, North Shields.

Formica Limited are to extend their chemists' laboratory at West Chirton, to plans by William Stockdale, 73 Howard Street, North Shields.

Whitehaven. Fleetwood Construction Company Limited, Fleetwood, have received a contract for the erection of a telephone exchange at Whitehaven.

Acton. More O'Ferrall & Pickard Limited, 22-26 Brunel Road, are to make extensions to their factory.

Douglas & Sons Limited, Gorst Road. Factory extensions.

Bolton. Bolton Turntable Company. Proposed extensions to works in Emmanuel Street.

Bradford. Watmoughs Limited. Proposed extensions to factory in High Street, Idle.

Brighton. T. S. Precision Engineering Limited. Plans approved for extensions to the factory at Hollingbury industrial estate.

Bristol. Betterwear Products Limited, 35 Heath Road, Downend. The contractors for the erection of a new factory are Harrow & Heales Limited, Coronation Road.

Burnley. Burco Limited, Waterside Mill, are to make extensions to their factory.

Cambridge. L. Eyres (Knitwear) Limited. The contractors for factory extensions are F. L. Unwin Limited, Histon.

Chelmsford. Page Optical Company Limited, Anchor Street Works, are to erect new workshops.

Cheltenham. Neata Products Limited. A new factory is to be erected at the junction of Mead Road and Churchill Road.

Chester. Joseph Musgrave & Co. Limited, St. John Street, have obtained a site at Sealand trading estate for a new factory.

Coventry. W. E. Jones (Tools) Limited, East Street, are to make extensions to their factory.

Croydon. Brooks Ventilation Units Limited. The factory in Gladstone Road is to be extended.

Brink & Thomas Limited, 196 Morland Road, East Croydon. Factory extensions.

Dartford. J. W. Janes & Co. Limited, 271 Lower Abbey Road, Belvedere, are to erect a new machine shop in Princes Road.

Dumfries. Imperial Chemical Industries Limited, Millbank, London SW1, Plastics Division. Erection of a new plant.

Edmonton. Glover & Main Limited. Extensions to the factory at Angel Road.

Great Eastern Cabinet Company Limited. Factory extensions.

Glasgow. Waverley Furniture Manufacturers Limited, 51 Mauchline Street, are considering extensions to their factory.

Guildford. Dowdeswells (1930) Limited. New factory on Woodbridge Meadows Estate. The architects are Scott, Brownrigg & Turner, 32 London Road.

Hull. A. Brown & Sons Limited. Extensions to the factory in Perth Street.

Isle of Wight. Decca Radar Limited, Albert Embankment, London SE11, are to develop Cowes Airport.

Leicester. The English Glass Company Limited, Empire Road, are to build a new factory on a site in Scudamore Road.

Littlehampton. Willboro Precision (Engineering) Limited. The machine shop at River Road is to be extended.

Manchester. Beaverbrook Newspapers Limited, Fleet Street, London EC4, are to extend their printing works at George Leigh Street. The architects are Owen Williams & Partners, 101 Wigmore Street, London W1.

Queenborough. Abbott Laboratories Limited, 8 Baker Street, London W1, are to build a new chemical works.

Sheffield. E. G. Laycock & Sons Limited, 22 Eyre Lane. A new workshop is to be built at Smithfield.

Stevenage. Mentmore Pens Limited. The architects for extensions to the factory are Trehearne & Norman, Preston & Partners, 83 Kingsway, London WC2.

Surbiton. Factory Holdings Limited, Wigmore Street, London W1. The architects for the new factory are Eley & Cornish, 25 Wigmore Place, London W1.

Sutton Coldfield. Brookvale Manufacturing Company Limited. Extensions are to be made to Reddicap Works.

Watford. H. L. Castle Limited, Victoria Printing Works, Water Lane, Gladebrook. A new factory is to be erected on the Holywell Industrial Estate.

Dennison Manufacturing Company Limited, Minerva Road, London NW10, are to erect a new factory on Station industrial estate.

Wellington. Joseph Sankey & Sons Limited are to extend their Hadley Castle Works.

West Bromwich. Steel Parts Limited, Brickhouse Lane. Works extensions.

James Halley & Sons Limited, Sams Lane. Works extensions.

Windsor. Factory Construction (Maidenhead) Limited, Maidenhead, are to build eleven factories in Arthur Road.

Edinburgh. The Scottish Division, National Coal Board is to build a £350,000 headquarters in Lady Lawson Street to allow concentration of all departments of administrative and technical activity within one building.

Fort William. Scottish Pulp (Development) Limited. A new £20,000 company is to investigate the scope for locating a new modern pulp mill in the Scottish Highlands. Four major English paper companies are associated with the plan. If satisfactory an £8m to £12m integrated plant will be located probably in the Fort William area.

Glasgow. J. & R. Snodgrass Limited, millers, are to construct bulk storage and handling plant at their premises at 10 Anderston Quay.

William Teacher and Sons Limited, distil'ers, of Glasgow. Extension to bonded store at Flemington Street, involving a canteen, garage, water tank and pump house.

Hawick. Lyle and Scott Limited. Building is to start shortly on a £10,000 extension to their Lynnwood factory.

Tobermory. A new knitwear manufacturing factory has been launched at Tobermory by Fullarton and Company of Johnstone, who already operate in this field.

Sheerwater, Surrey. Efco Limited are building another factory in the L.C.C. industrial development area at Sheerwater, near Woking, in Surrey. The site is a prominent corner position close to the factory of their subsidiary Electro-Chemical Engineering Company Limited. The new factory scheduled for completion early next year, will provide up-to-date facilities for the manufacture of special furnaces.

Cambuslang, Lanarkshire. Hoover Limited. Extension of 88,000 sq ft to the existing 162,890 sq ft factory of Hoover (Electric Motors) Limited at Cambuslang, Lanarkshire, leased from Scottish Industrial Estates Limited.

Sheerness. Paint production at Sheerness Dockyard is proposed by Hunter and Company in agreement with Building Developments Limited. They expect to employ 50 people initially.

CLASSIFIED ADVERTISEMENTS

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BEAVER
MACHINE TOOLS

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MACHINE SHOP SUPERINTENDENT OR PRODUCTION MANAGER

Main requirements:

1. Essentially a machinist with very good record of succeeding responsibilities in machine shop.
2. Tremendous drive and vitality *absolutely essential.*
3. Plenty of common sense.
4. Preferred age 30–35.
5. A neat and tidy mind which will desire to keep his workshop always very orderly.
6. Salary commensurate with experience.
7. We will remove free and assist with housing after proving.
8. Pension Scheme available if required.

Please send full details in correct chronological order to:

BALDING ENGINEERING,
NORWICH.

Machinery, Plant and Accessories For Sale

CHAINS of every type and finish. Hooks, Rings and Wireforms. A. J. PRATT & SONS LTD: Chain House, Woodbridge Street, London, EC1 CLErkenwell 3742/3.

"FRIGIDAIRE" Low Temperature Refrigerators. 49 in.w × 28 in.d × 34 in.h ext. Ex Large National User, suitable A.C. or D.C. Deep Freezing, Storage of Ice Cream, Frozen Foods, etc. Price £40.0.0 each. Domestic Refrigerators, Service Cabinets and Cold Rooms also available. A.R.C., 134 Great Portland Street, London W1. MUSeum 4480.

FANS! ! ! for Dust, fume extraction, air conditioning, compressors, accessories, motors, etc.; at considerably reduced prices. People say—"If only we'd known of you before. . . . Write for very interesting list. Bellangers, 306 Holloway Road, London N7. North 4117.

PUMPS for all purposes. R. L. Christiansen Limited, Wordesley, Stourbridge. Brierley Hill 78184/5.

FOR sale 'Metrovick' Infra Red Paint Stoving Equipment comprising 2 frameworks each fitted with 3–4 ft long 5·3 kW units. 415 volts, 3 phase, 4 wire Control Box with 2 energy regulators and spare starter interlocked for use with conveyor. In good condition. Situated London W.3 area. Reply Box No. MW 24, "Mechanical World", 31 King Street West, Manchester 3.

FOR SALE—2 wooden Slat Conveyors (a) 35′ 10″ long × 2′ wide. 3 hp Motor. (b) 24′ 3″ long × 18″ wide, 2 hp motor. In good working order. Box No. MW 25, "Mechanical World", 31 King Street West, Manchester 3.

Classified advertisements are inserted at the rate of 2/9 per line.

FOR Sale: Cyanide Hardening Plant. Capacity 10½″ × 15″, in first class condition with many extras. Apply Hydraulic Engineering Company Limited, Chester.

Patents For Sale or License

THE proprietor of British Patent No. 590328, entitled "Timing Control for Mechanisms", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 East Jackson Boulevard, Chicago 4, Illinois, U.S.A.

THE proprietor of British Patent No. 732322, entitled "Jogging Machine" offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 East Jackson Boulevard, Chicago 4, Illinois, U.S.A.

THE proprietor of British Patent No. 730326, entitled "Hydraulic Ore Hoist", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 East Jackson Boulevard, Chicago 4, Illinois, U.S.A.

THE proprietor of British Patent No. 753062, entitled "A method and apparatus for forming a true cylindrical surface on an elongated member, such as a crankshaft or a calender roll", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 East Jackson Boulevard, Chicago 4, Illinois, U.S.A.

METALLINE IRON CEMENTS

These Cements are imperishable, and adhere permanently to the metal. The repaired part can be filed, buffed or drilled same as the casting

Send for FREE Trial Sample

SOLE MANUFACTURERS:

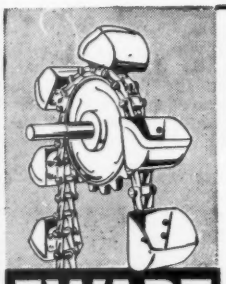
The METALLINE CEMENT Co.
10 Margaret Street, Glasgow C.1

BUFFALO HOTTOJET

for cleaning plant by a powerful jet of very hot water

Send for details

GREEN & BOULDING, Ltd.
162a Dalston Lane, London, E.8



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MALLEABLE IRON AND STEEL CHAINS FOR ALL DUTIES

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